S. A. E. JOURNAL

Published by the SOCIETY OF AUTOMOTIVE ENGINEERS, INC., *29 W. 39th St., New York*
Cable Address: AUTOENG *Telephone:* LONGACRE 7170

EDWARD P. WARNER, *President* COKER F. CLARKSON, *Secretary* C. B. WHITTELSEY, JR., *Treasurer*

Vol. XXVI February, 1930 No. 2

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The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.

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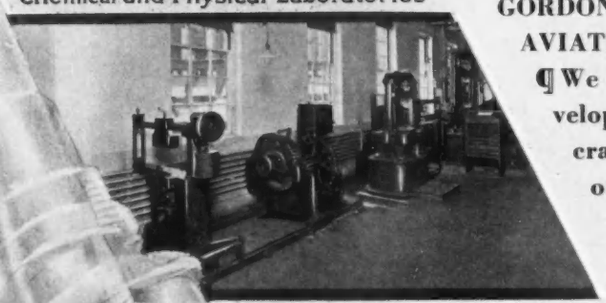

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S. A. E. JOURNAL

Vol. XXVI February, 1930 No. 2

Annual Meeting Largest Ever Held

Sixteen Sessions and Dinner on Five Consecutive Days Draw Attendance of 1233—All Activities Represented by Subjects Discussed

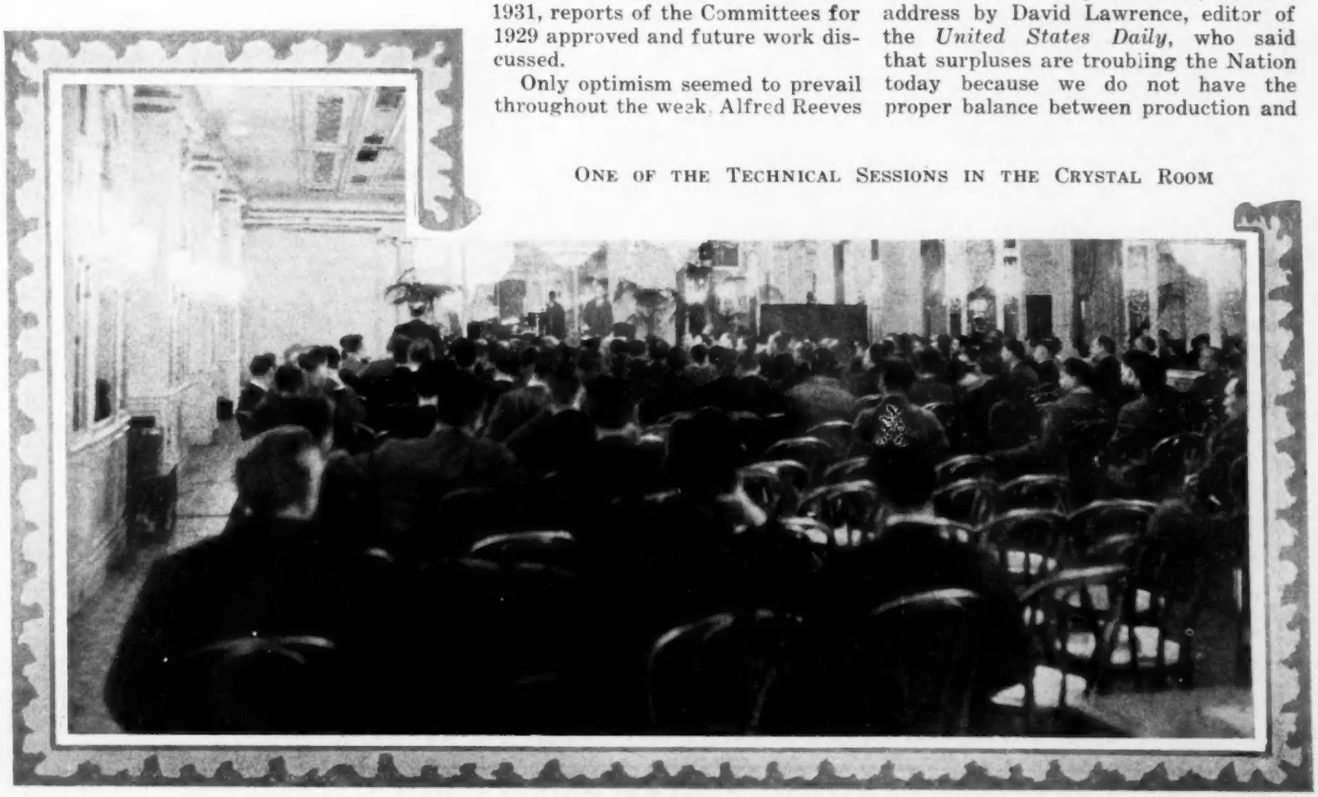
WIDENING and increasing interest in the manifold activities of the Society was reflected in the aggregate attendance of 1233 members and guests at the 1930 Annual Meeting held in Detroit last month. This exceeded by about 200 the attendance at the 1929 Annual Meeting. The dinner and session on Thursday night drew 810, who crowded the grand ballroom of the Book-Cadillac to overflowing, tables being set in the balcony and a dozen or more in the corridor adjoining the ballroom.

The record was broken, not only in attendance, but in the number of days occupied and of sessions held. In all, seventeen sessions, including the dinner session, were held during five consecutive days from Jan. 20 to 24, inclusive, with four sessions on two of the days. In addition, eighteen Council, administrative and Activity Committee, Subcommittee and Nominating Committee meetings were held, most of them being breakfast, luncheon or dinner gatherings in the small parlors on the ballroom floor. As a result, much business of the Society was accomplished and many plans made for the continuance of the work of the organization this year, the 1930 Council being organized, committee personnel announced, members elected by the Professional Activities to their respective Nominating Committees to nominate candidates for election as Vice-Presidents of the Activities for 1931, reports of the Committees for 1929 approved and future work discussed.

Only optimism seemed to prevail throughout the week. Alfred Reeves reflecting the general feeling in the industry in his address at the General Session on the third night, when he said that "the New York Automobile Show was the kick-off for 1930 business and astonished not alone our own industry but other industrial leaders by the extraordinary attendance and sales." He said that "this year the engineers will be at the throttle, turning on the steam which will enable the industry to make a successful run in the coming 12 months."

Challenged by Economic Problems

A more sober note was sounded at the dinner on Thursday night, arrangements for which were made by the Detroit Section Body Division, in the address by David Lawrence, editor of the *United States Daily*, who said that surpluses are troubling the Nation today because we do not have the proper balance between production and



ONE OF THE TECHNICAL SESSIONS IN THE CRYSTAL ROOM

Meetings Calendar

National Meetings of the Society

St. Louis Aeronautic—Feb. 18 to 20
Hotel Jefferson

Detroit Aeronautic—April 8 to 10
Book-Cadillac Hotel

Metropolitan Aeronautic—May 8
New York City

Summer Meeting—May 25 to 29
French Lick Springs

Chicago Aeronautic—August
(In conjunction with National Air Races)

February Section Meetings

Buffalo Section—Feb. 4

Hotel Statler
The Diesel Engine Industry and Aviation—R. H. Ward, Manager of *Diesel Power*

Canadian Section—Feb. 19

Royal York Hotel, Toronto; Dinner Meeting
Speaker—H. D. Alee, Studebaker Corp. of Canada

Chicago Section

No February Meeting

Cleveland Section—Feb. 10

Hotel Cleveland; Dinner at 6:30 p.m.
Evaluation Tests for Rubber Vibration Insulators—Franz D. Abbott, Firestone Tire & Rubber Co.
Compounding of Rubber for Use as an Engineering Material—V. A. Cosler, B. F. Goodrich Co.

Detroit Section—Feb. 17

Book-Cadillac; Dinner at 6:30; Ladies' Night; dancing
The Private Life of the Electron—E. L. Manning, Physicist in the Research Laboratory, General Electric Co.

Indiana Section—Feb. 13

Hotel Claypool, Indianapolis; Dinner Meeting
Review of Shows
Speakers—Delmar G. Roos, Chief Engineer, Studebaker Corp.; H. C. Snow, Chief Engineer, Auburn Automobile Co.

Metropolitan Section

A.W.A. Club, New York; Dinner Meeting at 6:30 p.m.
Address by Dr. H. C. Dickinson, U. S. Bureau of Standards

Milwaukee Section—Feb. 5

(Members to be guests of Allis-Chalmers Co., in the afternoon and evening)
Industrial Application of Tractors; Tractor Fuels

New England Section—Feb. 13

Hotel Kenmore, Boston; Dinner at 6:30 p.m.
Fundamental Facts Concerning Selling Service Labor—George T. Albright, General Service Manager, United Motor Service, Detroit
Service Management—Knox T. Brown, General Manager, Packard Motor Car Co., Boston

Northern California—Feb. 13

Engineers Club, San Francisco; Dinner, 6:30 p.m.
Engine Cooling—Carl J. Vogt, Instructor of Mechanical Engineering, University of California
Heat Transfer to Tubes through Liquid—Fred W. Dittus, Engineering Department, Standard Oil Co. of California

Oregon Section—Feb. 14

Automotive Steels and the Fundamentals of Their Heat-Treatment—S. H. Graf, Director of Engineering Research, Oregon State College

Pennsylvania Section—Feb. 12

Engineers Club, Philadelphia
Proper Preparation of Sheet Metal for Finishing—Frank P. Spruance, American Chemical Paint Co.
What We Use for Finishing Automobile Bodies and Why—George F. Farnsworth, Director, Detroit Laboratories, Budd Body Corp.

Pittsburgh Section

No February Meeting

Southern California Section—Feb. 7

City Club, Los Angeles
Gasoline—Including discussion of Vapor Lock and Detonation

Washington Section—Feb. 19

City Club; Dinner Meeting
Under the Cowling—T. T. Neill, Engineer in charge of Commercial-Aircraft Engines, Type Casting Laboratory, Bureau of Standards

distribution. The social-economic problems of today are challenging the automotive industry as no other industry is being challenged, he said, and "the men in it who have given for a dollar the greatest single value in a manufactured article will find a solution and will be inspired to go forward because the entire Country has confidence in your genius and your ability."

Program Followed Without Hitch

The extensive program for the meeting was followed through on time with no omissions and no rearrangement of order except at one session. Every session Chairman was on hand to conduct his meeting, and did so with expedition and in a manner that held the interest of the audience to the end. A larger aggregate volume of discussion was brought out than at any previous National meeting of the Society.

Good attendance at nearly every session reflected credit upon the Meetings Committee and the Technical Committees of the several Professional Activities, which arranged the program, for their selection of subjects of immediate interest and importance and the choice of speakers well qualified to discuss them. The attendants obviously were well satisfied with the meeting as a whole and felt that they had got much useful information from the individual sessions. Throughout it was a serious affair devoted to earnest discussion of new developments and ways and means of improving the design, production, performance, operation and maintenance of automotive vehicles of the highway, air and water.

Reports of the individual sessions follow, with synopses of the contents of the papers and discussion. Also in this issue of THE JOURNAL are given reports of the Council and Committee meetings, personnel of the Administrative, Professional Activity and other Committees for 1930, Committee Reports for 1929, and a report of the Annual Business Meeting.

Lawrence Surveys the Situation

Presents Challenging Problem in Dinner Address to 810 Members and Guests

AFTER brief prefatory remarks at the Dinner Session, on Thursday evening, by the incoming President, Edward P. Warner, and a few minutes of greeting from the Hon. Fred W. Green, Governor of the State of Michigan, the speaker of the evening, David Lawrence, editor of the *United States Daily*, was presented. He took as his text two outstanding paragraphs from the report of the Committee on Recent Economic Changes, which he quoted as follows:

> Economists have long declared that consumption, the satisfaction of wants, would expand with little evidence of satiation if we could so adjust our economic processes as to make dormant demands effective. Such an expansion has been going on since the beginning of the industrial revolution. It is not a phenomenon of the postwar period, except in degree. But it is this degree of economic activity, this almost insatiable appetite for goods and services, this abounding production of all things which almost any man can want, which is so striking a characteristic of the period covered by the survey.
>
> It was during the period covered by the survey that the conception of leisure as "consumable" began to be realized upon in business in a practical way and on a broad scale. It began to be recognized, not only that leisure is "consumable," but that people cannot "consume" leisure without consuming goods and services, and that leisure which results from an increasing man-hour productivity helps to create new needs and new and broader markets.

Production-Distribution Balance Needed

Mr. Lawrence said in part:

"In the ten years that have passed we have mastered, it seems to me, the problem of production; and we have amassed great surpluses, surpluses that are troubling us today because we do not have the proper balance between production and distribution. It seemed only necessary to produce in the last ten years; markets were readily found.

GOVERNOR FRED W. GREEN, OF MICHIGAN

Who Welcomed the Members of the Society at the Dinner and Told Several Humorous Anecdotes

"The European world consumed many of our products. Their own productivity had been impaired by the war, and we merely had to fulfill a demand that was existent. We did not have to awaken any dormant demand. So our surpluses rose. I mention these other surpluses and these other industries so that you may see how the problems of the automotive industry are related to those of all other industries, that you may see yourselves in the perspective of modern economic evolution.

Surplus of Production

"It will take us a few years to balance production and distribution, but we have started with Government aid, to be sure, not because the Government is the only paternalistic factor to which we can turn, but because the Government is the pioneer; it is the institution to which we turn when we need some new trend, when we need some new assistance in order that private capital and private enterprise might better understand and might more confidently attain a solution of the same thing. The power of example of the Government is great; that is why in agriculture we turn to the Government for an example, for a method of solving this problem of distribution.

"We have a great surplus in oil. Voluntary cooperation is urged first, restriction by legislative act of the States, great questions of balancing production in certain oil fields with demand, and now a world-wide problem, too, balancing production in the domestic United States with production in other parts of the world.

"We have a surplus of mines and miners. We have a surplus in the textile world. We all know what the trouble is with the tariff on sugar. We produce more sugar in continental United States and in the Philippines and in Cuba than we can consume. There is a surplus there. An economic effort to restrict it, either by a tariff wall or rationing the supply that may be imported from the Philippines or from Cuba, is seen.

"Last, but not least, we had the phenomenon of a surplus of credit. It sounds like a paradox to say we had a surplus of credit. What we really had was an extravagant use of credit in a particular channel, and there we threw the economic balance out of its equilibrium because credit was not unlimited. There was a surplus, but it became scarce within a certain channel, a speculative channel, until it broke that particular avenue of exit and turned back

DAVID LAWRENCE
Editor of *United States Daily*, Who Spoke at the Dinner on the Economic Situation

into the normal channels in which it should have flowed in the first place.

Period of Credit Readjustment

"We are in the middle of a period of adjustment of credit. We had an abundance of credit after the war, we found ourselves with a large wealth on which we could erect a great credit structure. We soon found that in our desire to discover new uses for that credit we could inflate, and we did inflate. So we went on through this period of great production and great and intensive use of credit in a speculative sense until we came, a few weeks ago, to a parting of the ways. We did not come to the end of an era. I doubt seriously whether there was any phenomenon, any extraordinary characteristic, about the last ten years. No economist who is really at all familiar with the processes of our times will argue that the last ten years contains anything new by way of fundamentals. It did contain a more intensive activity in certain lines, it did connote a rearrangement of fundamentals and a new economic balance, but the fundamentals were the same.

"We have been organized for this particular venture for ten years because we began in the last few years to give thought to trade organization. You, with your Society of Automotive Engineers and your trade bodies, which are related to this particular industry, know how helpful your trade organization has been. All of these things have led to a common thought and a common understanding of the problems of the hour.

"If you take that excerpt from the Committee report and analyze it, you will see that the great future of this Country depends upon the increase of leisure. That is not merely a fantastic statement about a shorter week; it is really a statement of how to increase man-hour productivity. That is the great goal of a good living-standard. It has a direct relationship to the power of the people to consume goods and services, among which, of course, is the automobile.

"This Country is no longer provincial. We have today a greater export market than we ever had before, in all goods. We have become world-wide in our viewpoint in international affairs, because we have been forced to do so. We have a greater interest in the success of the conference at London today than we had in the prevention of war in 1914. Why? Because we have such a large export trade. We have a material stake in peace. It does not detract one iota from the matter because we have a material stake working hand in hand with a great moral force. I say it is a material stake, but it relates indirectly to our lives, to our opportunities to enjoy leisure, to our opportunities to purchase more, because the budgets of all nations are affected by the amount of money that will have to be spent for national defense.

"The great problem of the next few years in Government is how to keep down taxes. It has just dawned on the American people that they are spending more money and raising more money through taxation than at any time in the history of the world. That is not true merely of the Federal Government. Expenditures of the Federal Government have varied very little in the last few years, but they have gone up materially in the States and cities.

Automobile a Standard of Living

"The psychology of the present day is to accept the automobile as a fundamental of a good living standard. We cannot recede from that; we must start with that premise. If we understand that it is a fundamental in a better living standard, we must go further and analyze what we may call, technically, the demand. We have quickened our whole life by automotive transportation. It seems to me that, as the average man becomes more and more acquainted with transportation by the automobile, he is going to become more discriminating, he is going to wonder about this problem of replacement which has so much to do with consumer confidence.

"The automobile industry has the whole world before it. It is being challenged now as no other industry has ever been challenged and, having in it men of genius, men of creative ability, men who by their research have startled the world, men who have solved the problems of mass production, men who have given for a dollar the greatest single value in a manufactured article, these men will find a solution and will be inspired to go forward because the entire country has confidence in your genius and your ability."

The Economics of Production

Dean Kimball, in an Extemporaneous Address, Draws a Clear Picture of a Difficult Subject

SOME of the fundamentals of production cost were made to seem definite and simple to an audience of about 200 at the Production Session on Monday evening by Prof. Dexter S. Kimball, dean of engineering at Sibley College, Cornell University. Dean Kimball was very heartily applauded at the conclusion of his address, and after adjournment the members were enthusiastic in their comments.

Leading up to his introduction of the only speaker of the evening, Chairman E. P. Warner referred to the recent modification of the fundamental structure of the Society through the recognition of professional activities, such as Production and Transportation. He expressed some fear that the idea sometimes gets abroad that the Production Activity is concerned only with the production of highway vehicles and that the sole interest of the Transportation Activity is with highway transportation. Essentially, however, the division upon lines of research, design, production, operation and maintenance runs across the entire group of automotive industries. The airplane and airplane-engine men and the members concerned with the engineering of motorboat powerplants are concerned also in the work of the Production Division.

Similarly, President Warner prefers to avoid use of the terms "theory" and "theoretical," which to many connote a sharp boundary between theory and practice, a division that probably does not exist in reality; there is a theory of production, or a region between design and production that is of intimate common concern. It is mathematical or engineering science applied to production; that is, the facts of production tied in with design, management, and

general planning of an industrial program by the application of analysis based upon economic laws.

From Simple to Abstruse

Dean Kimball sketched in a semi-technical talk the rise of production engineering from the last half of the 19th century to the present time and in conclusion predicted that in another 25 years the present problems will be solved and we shall see a development of the economic background of production that is going to be as scientific as engineering is today. This will involve the application of economic principles which he explained in the course of his talk and will give as good control of production as the engineer now has of his design-engineering problems. These principles have been known for many years but we have not known how to apply them. Today, he said, the greatest demand the colleges have is for young men who can do this sort of thing. Some of the young college men have made remarkable strides in this direction and have an advantage over the old type of foreman or superintendent, who will pass out of the picture in all high-grade production in a few years, as the old empirical engineer passed out in powerhouse work.

Basic Laws of Production Explained

Some of the basic laws of production were stated and illustrated with charts drawn on the blackboard. The first of these was the principle of the division of labor, which was the starting point of Adam Smith's basic book on economics. This principle probably has been carried farther in the automobile industry in this Country than in any other industry. Smith started with the assumption that low wages necessarily went with low cost, but a new economic theory that high wages and low cost go together is coming into our industrial field, and that high wages and high spending make prosperity. As we do not yet know whether these new theories are true, Dean Kimball said he would stick to the principles that are fairly well agreed upon.

He showed by curves and simple mathematics that as production increases the cost per piece decreases but at some point a quantity is always reached at which the curve ceases to drop and even begins to rise. This is the effect of the law of diminishing returns. It is inescapable, but nobody knows just where the point of lowest cost is located on the production curve, as we have no history of that kind. This law, which is now coming to be called the law of diminishing productivity, is really simple; it involves the so-called law of factors.

In any production whatever more than one factor is involved. If a major factor such as machinery is producing at a high rate of efficiency, usually all the other factors are running at a greatly reduced rate of efficiency. Very rarely can two, and almost never three, factors be made to work at high efficiency. For example, in New England knitting and weaving mills where 1000 looms work at high speed, the attendants caring for them have considerable leisure; their duty is simply to watch the looms and be ready instantly to restart a loom stopped automatically by a broken thread. There must be an excess of attendants to keep the machines in constant operation. Similarly, in an Ithaca chain works a flying squad of repairmen loaf most of the time, but so long as they are loafing the plant is making money because the machines are running. As production goes up, some of the factors that enter into diminishing returns are idle periods, overhead, clerical help and so on that also increase.

Mathematical Problems Enter

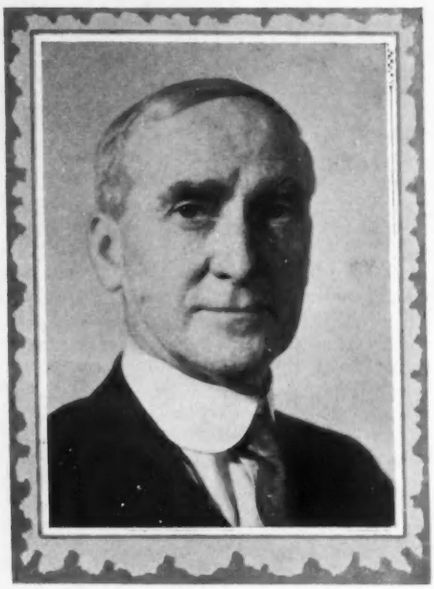
Some very definite mathematical developments are now coming into the field of production management, according to Dean Kimball, who said that the problems are of two distinct types and are going to require pretty stiff mathematics. In materials handling, for example, balance-sheet methods of debit and credit are used, on one side being placed all the probable gains from introducing machinery and on the other side all the possible costs or losses. The columns are then balanced to decide whether the apparatus will pay for itself. The other problems are much more complex and are entirely out of the hands of the shop foreman or superintendent or any man who has not been trained mathematically, as it involves calculus, the maxima and minima, to determine the most economic number of pieces to be made.

Into such problems enter such questions as the setting up of the machinery, variation in cost of materials, the question of labor and so on. Six or seven variables all change every time a change is made in the quantity. The only way in which the problem can be solved is by putting all the variables into terms of one variable and use calculus, finding the minimum and the maximum. One little factory near Ithaca runs on such a formula to ascertain the most economical manufacturing lot; no material is bought that is not computed by the formula. If material is bought at one time for a large production lot, interest on the investment as the material lies in the storeroom enters into cost of the product. If one manufactures once, twice or three times and finished product accumulates in the stockroom, the interest lies in the stockroom. There is interest also on the material in process. So, numerous variables enter into the problem.

One thing that is certain is that in a short time all wise men will be scheduling their material by formula; the ideal method is to have material flow into the factory on one side and go out of the factory directly into the car for shipment. Production control requires an absolute knowledge every day of what one has, where he is going, when he should order, and what the maximum or the minimum of parts or pieces should be. That is a form of control that has not been touched as yet in most places; it takes us off into a field which the ordinary man in the shop knows nothing about and where the technically trained man has to be called in. And that is coming rapidly.

When Chairman Warner called for discussion, John Younger, of Ohio

MEMBERS RECEIVING BADGES AT THE REGISTRATION AND INFORMATION BOOTH



DEAN DEXTER S. KIMBALL

Professor of Mechanical Engineering at Cornell University, Who Put Human Interest into the Subject of Production Economics in the Only Address at the Production Session

State University, said that Dean Kimball's references to the leisure of certain machine attendants caused him to think of the social value of leisure but he could not see its efficiency. Which reminded him of the story of a Scotch woman who was seated in a chair operating a churn with her left foot, rocking a cradle with her right foot, knitting with her hands and reading a paper. One efficiency engineer, observing her, said, "At last there is a woman who is 100 per cent efficient." But his companion engineer said, "Oh, no, she is only 80 per cent efficient. She might be sitting on a cheese, pressing it."

Gospel of Simultation

This, said Mr. Younger, led him to the thought of the old law that E. P. Blanchard, former Chairman of the Society's Production Committee, put into a new form and called the law of simultation, the doing of two or more operations simultaneously and in harmony, each with the greatest efficiency. Isn't it more efficient, asked Mr. Younger, to have two fixtures for a machine so that the operator can be loading one while the machine is working on the other? That is the gospel that is preached in the modern shops today.

An analogy that he thought indicates the necessity of having mathematical laws in production work was drawn by Mr. Younger between the orderly movement of the heavenly bodies, all obeying one marvelous mathematical law, and the perfectly-timed mass production on an assembly line moving at a definite pace, with the engine line feeding in engines at exactly the right time, and all the other parts lines doing the same. If the earth should be moved a little off its course, a celestial catastrophe would result; and if one part going through the lines of production should be stopped, that would be as big a catastrophe, in the eyes of a production man. To Mr. Alvord we owe a debt of gratitude, said Mr. Younger, for starting the idea and formulating the laws of management.

Factor Control by Uniform Flow

F. L. Faurote, of New York City, asked if it were not possible to control three or four factors instead of only one or two, in modern production, so as to bring them to a high degree of efficiency. For example, in the use of a multiple automatic machine in conveyor process line, advantage could be taken of the fact that several operations could be done at the same time; such factors as rent chargeable to space occupied, transportation of the part, processing, handling and man-power could be known and controlled. The man could employ almost his full time in preparation of the work and feeding the machine. He asked also if the inventory could not be controlled in a plant in which the steel stock is passed right through without being stored at any time, as in the Hudson and Ford plants.

Dean Kimball replied that the nearer the output can be kept at a uniform flow, as in some powerhouses, the nearer the minor factors can be brought to the maximum or minimum size; the coal apparatus, feed-pumps and blowers can operate at greater efficiency. So, on an assembly line, with continuous production, one might get many good factors, and the simpler would become the problems of wages, administration and everything else.

Assuming balanced production and consumption and balanced distribution at a specified point and time, Mr. Faurote inquired how one can make sure that these will continue so that there will be a continuous flow. In response, Dean Kimball said that the only way is by prognostications such as are being carried on by men looking ahead, as at the Harvard Economic Service and by Howard Cooney, of the Walworth Mfg. Co., who laid down a sales program and budgeted manufacture by the Harvard B-curve. This is plotted in dollars and years and embodies three market indexes. Mr. Cooney found that his sales for several years followed right along the curve and, projecting a production program on this basis, he struck within 2 per cent of the company's sales the following year.

Carburetion and Distribution

Problem of More Perfect Utilization of Mixture Discussed —Cold Carburetion To Become Practice

THE OLD problem of uniform distribution of the fuel-air mixture to the cylinders was discussed again at length at the Wednesday forenoon session, attended by about 200 members. Alex Taub, of the Chevrolet Motor Co., presented the only paper on the subject, and written discussions were given by Robert N. Janeway, of Detroit; L. C. Price, of the University of Arkansas; and Claude E. Kegerreis, of the Tillotson Mfg. Co.

Cold Carburetion was the subject of the only other paper of the session, which was presented by Carl L. Kindl, chief engineer of the Delco Products Corp., and drew forth much favorable oral discussion.

Distribution Fundamentals Reviewed

Mr. Taub's paper, which will be published probably in the March number of THE JOURNAL, was written with the object of encouraging continued discussion and dissemination of information on the fundamentals of distribution routine so that solution of the problem of more economical and efficient utilization of the fuel may be arrived at earlier. The author reiterated known facts, including the method of charting distribution progress, made a suggestion for locating the error in distribution, and gave a series of thoughts on the subject. The first part of the paper is a study of distribution routine, and the second part consists of a discussion of a few of the problems that are met every day in the search for perfect distribution.

Absolving the carbureter from blame, Mr. Taub said that fundamentally the major project in manifold design is to keep the fuel in the airstream; if this could be done easily, all that would be necessary for good distribution would be to obtain uniform air-flow through each leg of the manifold. A poorly divided airstream and uncontrolled precipitation of the fuel are the chief enemies of good distribution. Balancing of the airstream in manifold arms of non-uniform length, manifold and valve-size control of precipitation by the application of heat, means used to divide the wet fuel accurately and

keep it in the airstream by correct design, and the application of the principles outlined to correct manifold designs for six and eight-cylinder engines are some of the phases of the subject covered. The paper was illustrated with numerous lantern slides.

Written Discussion Submitted

Chairman F. C. Mock, now research engineer of the Bendix Aviation Corp., commenting on the paper, said that he was impressed with the quantity of the intelligently planned and directed research work done and the quality that Mr. Taub developed in the work. One of the thoughts that had been emphasized and which Mr. Mock hoped would be considered in the discussion is the need of a common method that can be followed in general by all who are working on this problem. The method of plotting the fishhook curves shown with the paper seems to depict better than any previously seen the economy characteristic of the given set-up of carbureter, manifold and engine under consideration. Another method that he said is somewhat novel in American practice is the use of mixture ratio throughout the work, which involves measuring the air-flow to the engine as well as the fuel flow. Mr. Mock believes it will be worthwhile developing a convenient, quickly read method of measuring the air-flow, which would save time in development work. With our present highpower automobiles, we are using little less power at 20 m.p.h. than at 90 m.p.h. In a study of the subject the friction horsepower is a disturbing element, and if the air-flow to the engine can be measured under such conditions it will provide an additional checking factor.

Ideal Fishhook from Fuel Converter

The real value of the fishhook for analytical purposes, said Mr. Janeway in his discussion, lies in the fact that it defines the conditions of maximum power and maximum economy. To be really useful, these conditions must be defined in terms of air-fuel ratios, and he recommended that Mr. Taub's method be amended to the extent of plotting the curves against relative total fuel consumption at full load, because the full-load fishhook is particularly useful in obtaining a quantitative measure of distribution.

Referring to an apology made by Mr. Taub for his inability to show an ideal fishhook, Mr. Janeway showed a lantern slide of such a curve obtained on a six-cylinder overhead-valve engine at 1000 r.p.m. at full load superimposed on a curve from a single-cylinder engine in which the leanest air-fuel ratio for maximum power is 14.4 to 1. The almost complete agreement of the two curves was obvious, especially with regard to the mixture ratios at leanest for maximum power and at maximum economy. The obtaining of this ideal distribution is the result of an entirely new departure in manifolding which is being developed by the Automotive Devices Corp., said Mr. Janeway, who showed slides of the construction of the new fuel-converter manifold and explained its principles and operation.

Briefly, this consists of a metal cone in the manifold riser, the cone being wound with braided wire and having an absorbent surface located in the airstream, which soaks up the liquid fuel. The cone is heated by exhaust gas and vaporizes the liquid fuel trapped by the absorbent winding. The device thus provides a dry mixture by concentrating the heat upon the fuel and makes possible perfect distribution without sacrifice of volumetric efficiency by excessive heating of the mixture. It is believed that the principle involved makes possible the practical solution of the problem of distribution, concluded Mr. Janeway, and it is hoped that it will soon be possible to present complete data on this device.

Results of Arkansas Tests

Mr. Price described tests made at the engineering experiment station at the University of Arkansas in an investigation of fuel distribution in a three-port six-cylinder engine. All tests were made with a cold manifold, with several different carbureters and with the carbureter horn turned in different directions. By means of separators installed between the manifold ports and the engine ports, the investigation was confined to distribution among the three ports rather than among the six cylinders. By this means slightly more than one-half of the gasoline that went to the carbureter was recovered. The liquid collected at each separator is an index only of the amount of fuel fed to that engine port, and is a measure of the relative mixture-strength only if the manifold supplies equal quantities of air to the several ports. Hence the logical starting point in any investigation is to design the manifold so that the branches will supply such equal quantities of air. By the use of a manifold designed at the University, a cross-section of which was shown on the screen, an improvement of 24.6 per cent based on the worst operating condition of the engine was obtained.

Carbureter Man's Viewpoint

Mr. Kegerreis's contribution was from the viewpoint of the carbureter man and discussed the various phases of the subject, arriving at the conclusion that the gist of the matter is contained in three factors: (*a*) well-balanced air distribution, (*b*) an effective distributing design, and (*c*) final assistance rendered to the mixture by proper application of heat for fuel vaporization.

As the carbureter engineer usually is called upon to adapt the carbureter to whatever conditions the particular engine has integrally built into it, his task is to consider seriously how to obtain satisfactory distribution, and it is encouraging to find an engine designer urging cooperation of the engine designer with the carbureter engineer in working out manifold troubles, as Mr. Taub had done, as it will enable the carbureter man to recommend changes in the induction system built into the engine instead of having to change the carbureter characteristics, often warping them very badly.

Cold Carburetion Advocated

In his paper on Cold Carburetion, which appears in this number of THE JOURNAL, beginning on p. 159, Mr. Kindl presented in admirable manner a radically different system of carburetion in which no heat is applied and the fuel is not vaporized before reaching the ports, being conducted to

CHAIRMAN AND SPEAKERS AT THE MIXTURE-DISTRIBUTION SESSION

F. C. Mock, of the Bendix Aviation Corp., Who Presided; Alex Taub, of the Chevrolet Motor Co., Who Gave a Paper on Mixture Distribution; and Carl H. Kindl, of the Delco-Remy Corp., Who Told of the Development of a System of Cold Carburetion

the ports through small-diameter tubes located in but separate from the air manifolds. What the final result of this development will be is difficult to predict, according to Mr. Kindl, as the system involves some difficult problems, but its advantages are so great that cold carburetion should soon become commercial practice.

Much discussion followed the presentation of the paper and the author was called upon to answer many questions regarding it and the results obtained. This was participated in by Chairman Mock, T. J. Litle, R. W. A. Brewer, C. W. Smith, Harold Caminez, H. M. Jacklin, E. E. Dean, M. R. Wolfard, Harry Huf, T. S. Kemble, C. H. Taylor, Neil MacCoull, J. M. Davies, W. E. England, C. H. Larson, S. M. Udale, J. B. Macauley and others.

More Power and Quicker Starting

Answering some of the questions, Mr. Kindl said that the system is a cheap way of getting more power out of the engine, which is the more important factor from the standpoint of the car manufacturer and engine designer; while to the car user the factor of most value is the cold starting and driving away in winter. The increase in power varies with the design of engine from 7 to 13 per cent, taking advantage of the possible increase in compression without increase in detonation. Some tests indicated that the liquid fuel cannot be delivered directly into the combustion-chamber without producing some undesirable results, but just how much mixing with air is necessary is not yet known. There is practically no difference as regards ignition when starting. Crankcase-oil dilution is less, because inherently good distribution is obtained as soon as the engine is started when cold and the mixture in all cylinders is rich, so they all fire.

Mr. MacCoull referred to the apparent idea that there must be unvaporized liquid fuel in the combustion-chamber on the compression stroke, which he said was not a fact, as the inlet valve and residual gases are very hot and will vaporize the liquid fuel before the firing stroke. As for oil dilution, experiments made some years ago gave evidence that the gasoline that gets into the crankcase is that which is absorbed from the vapor by the oil film on the cylinder-wall, and whether the mixture is heated or cold makes virtually no difference.

Application to Aircraft Engines

Mr. Caminez raised the question of application of cold carburetion to aircraft engines, and Mr. Mock pointed out that the chief reason for application of heat to the carbureter on such engines is to prevent freezing of the fuel. Mr. Udale, however, stated that during the war it had been found that delivering the fuel after the throttle eliminated freezing at the throttle, and he thinks that as far as aircraft are concerned, cold carburetion is in the right line of development.

Mr. Macauley referred to another possibility, mentioned to him by Mr. MacCoull, of using in the cold-carburetion system the large quantities of lighter fractions of gasoline that are available at a price not in excess of the heavier fractions now being used but which cannot be used because there is too much heat in the fuel system, which causes trouble with vaporization. If the heat were kept where it is wanted, substantial improvement in distribution could be made by designing fuel systems that would render it possible to use these large quantities of lighter gasolines.

Fuel Research Progress

Vapor-Lock, Detonation and Engine Acceleration Investigations Reported upon at Two Sessions

THE causes of vapor lock in automobile and aircraft engines, the results of acceleration tests made by Bureau of Standards men in four of the large-production automobile manufacturers' laboratories, and data throwing a new light on detonation problems, were the subjects which brought a record attendance at the two fuel sessions held on Tuesday, Jan. 21.

W. S. James presided at the Cooperative Research Session in the forenoon, at which reports from the Bureau of Standards stimulated an unusual amount of discussion disclosing very interesting first-hand information on the subjects presented.

The light ends of the gasoline constitute the main factor in producing vapor lock in automobile and aircraft engines, according to the data reported by Dr. O. C. Bridgeman in his paper entitled, The Properties of Gasoline with Reference to Vapor Lock. The author showed that the presence of dissolved air, water and carbon monoxide in the gasolines has a negligible effect on the vapor-locking tendencies of the fuel, and he presented measurements which indicate that the temperature at which a given fuel will vapor-lock corresponds to the point at which 10 per cent is boiled off in the ordinary A.S.T.M. distillation corrected for loss.

Dr. Bridgeman's paper constitutes a summary of the work carried on at the Bureau of Standards under the direction of the Research Committee of the Society with funds provided by the Naturaline Co. of America. Within the last few months the supervision of this investigation was taken over by the Cooperative Fuel-Research Steering Committee because of the vital importance of the vapor-lock problem to both the petroleum and the automotive industries.

In both the paper and the extensive discussion that followed its presentation, the fact was emphasized that the 10-per cent point of a gasoline must be low, preferably below 160 deg. fahr., to assure easy starting in cold weather, and that, if gasolines are to meet such a specification with a reasonable leeway, it is virtually necessary that the gasoline induction systems be so designed that the temperature of the gasoline never exceeds 140 deg. fahr. This means that the gasoline feed-lines, vacuum tank, carbureter, and so forth should not be in too close proximity to the exhaust pipes or other sources of heat. It is the responsibility, therefore, of the designing engineer to keep these points in mind if vapor lock is to be avoided with easy-starting gasolines.

In the discussion, experience was reported with gasoline temperatures as high as 270 deg. fahr. in the fuel line and 160 deg. in the carbureter float-bowl. Such conditions are certain to cause serious trouble from vapor lock.

It was also emphasized that lines handling the gasoline should be reasonably large in cross-section and that sharp changes in direction or constrictions should be avoided, as these design features tend to increase the gas-locking tendency, other things being equal. The vacuum-tank systems were said to give less trouble generally from vapor lock than gasoline-pump systems, which was attributed to the fact that the ordinary vacuum-tank system boils off a considerable amount of the light ends of the gasoline under hot-weather conditions.

Industry Aiding Acceleration Research

The spirit of cooperation which has become increasingly prevalent in the automotive industry resulted recently in letting down barriers as old as the industry itself. Four of the large automobile companies extended to the Bu-

reau of Standards Engineers, working under the direction of the Cooperative Fuels Research Steering Committee, the privilege of carrying on cooperative tests in their respective research laboratories. Formerly the research laboratory was the holy of holies, from which no secrets were permitted to escape; now the results of these tests are available for the benefit of all, in the paper entitled, Effect of Design on Engine Acceleration, by D. B. Brooks and C. S. Bruce.

The object of these tests was to determine whether engines of different designs would show the same general trends with respect to acceleration with a series of fuels heretofore tested on a single engine at the Bureau of Standards. It was found that, while for a given improvement in the volatility of the fuel, one engine would show three times the improvement in acceleration that another of different design would show, engine design is much less important than is manifold design. Some idea of the magnitude of the work involved can be obtained from the fact that, in working up the results of the 600 test runs, nearly 100,000 computations were made.

The special portable accelerometer designed for use in these tests records precisely the performance of the engine and is hailed as a practical and simple means of measuring acceleration performance that has heretofore required a considerably more complicated procedure.

Atmospheric Effects on Detonation

An intensive study of the precision of detonation test-methods is an important phase of the program laid out by the Subcommittee investigating this problem under the direction of the Cooperative Fuel-Research Steering Committee. Tests are now under way on the experimental knock-testing engine developed by the Subcommittee on Methods of Measuring Detonation to determine the effect of factors that influence detonation so that these variables may be classified as being negligible or requiring control or correction.

D. B. Brooks, in his paper on Influence of Atmospheric Conditions on Knock Testing, gave the results of some preliminary experiments made at the Bureau comparing the results of antiknock tests of various gasolines made while varying the atmospheric conditions of air pressure, temperature and humidity. Mr. Brooks showed that normal changes which are likely to be experienced in the humidity and temperature of the test room have very small effects on the antiknock values recorded.

The paper is by no means either complete or conclusive, but is merely a progress report on work undertaken with the object of ascertaining the order and magnitude of errors likely to be introduced by variations in atmospheric conditions. It considers the normal and the extreme ranges of these three factors.

Conclusions Drawn from Knock Tests

To the experimental knock-testing engine was attached apparatus for the control of air temperature and humidity. Slides showing the effect of these various factors on both relative and absolute detonation were exhibited, and the following conclusions drawn: (*a*) the effect on relative detonation of day-to-day variation in atmospheric humidity is negligible in winter and small in summer; (*b*) the effect of variations in humidity occurring between successive detonation tests is negligible unless made under abnormal conditions and with an interval of more than 2 min. between tests; (*c*) in rating fuels for knock, normal air-temperatures should be maintained reasonably constant, that is, in a range not exceeding 5 deg. cent. (9 deg. fahr.) and (*d*) that tetraethyl lead is preferable to benzol as a standard knock suppressor when used in Pennsylvania-base gasoline in knock rating at varying temperatures.

The list of other factors influencing detonation which will be investigated in turn by the Bureau of Standards as well as other members of the Subcommittee was included in the program printed in the Automotive Research section of the July issue of THE JOURNAL.

In the discussion which followed Mr. Brooks' paper, information was developed to show that the spark has considerable influence on detonation; that is, both the spark-plugs and the sparking voltage. This variable was not originally included in the Subcommittee's program but undoubtedly will be included later.

Data on Suggested Reference Fuels

The entire session Tuesday afternoon was devoted to the subject of detonation and was conducted by Past-President H. L. Horning in his characteristically interesting and inimitable manner.

The three principal requirements of any system of measuring the antiknock quality of a gasoline are, first, a standard engine; second, a standard procedure; and, third, a standard fuel. Progress toward the first two has been previously reported. The paper prepared by J. M. Campbell, W. G. Lovell and T. A. Boyd, entitled, Detonation Characteristics of Some of the Fuels Suggested as Standards of Antiknock Quality, and presented by Mr. Campbell,

CHAIRMAN, SPEAKERS AND DISCUSSERS AT THE COOPERATIVE-RESEARCH SESSION

(Top, Left to Right) W. S. James, of the Studebaker Corp., Chairman; Dr. O. C. Bridgeman, Who Reported on Vapor-Lock Investigation at the Bureau of Standards; and L. C. Price, of the University of Arkansas, a Discusser

(Bottom, Left to Right) D. B. Brooks and C. S. Bruce, of the Bureau of Standards, Co-authors of a Paper on Effect of Design on Engine Acceleration; and Prof. George G. Brown, of the University of Michigan, Who Discussed the Several Papers

CHAIRMAN OF THE DETONATION SESSION AND AUTHORS OF ONE OF THE PAPERS

H. L. Horning (Left), Chairman of the Research Committee, Who Presided; J. M. Campbell, W. G. Lovell and T. A. Boyd, of the General Motors Corp. Research Laboratories, Joint Authors of the Paper on Detonation Characteristics of Some of the Fuels Suggested as Standards of Antiknock Quality

treated the last-named subject with comprehensive brevity, giving valuable absolute and relative data. On a diagram included in the paper valuable fundamental data were given on such possible standard fuels as alcohol, toluene, benzene, iso-octane, cyclohexane, normal pentane and normal heptane.

Because of the technical character of the information, few who attended the session were sufficiently acquainted with the data to carry on any considerable discussion. To those executives, engineers and users, however, who have not followed the laborious detailed work of securing precision in detonation measurements, the paper will bring a better realization of the intricacies of the problem and the full importance of its successful conclusion. The paper is printed in this issue, beginning on p. 163.

Move Toward Uniform Test Methods

A decisive step toward the goal of universal acceptance and application of a standard method of measuring knock was taken recently when the Subcommittee, composed of representatives of the petroleum and automotive industries, working toward that end in the United States, negotiated the cooperation of a similar group in Great Britain. Arrangements are now under way to supply identical equipment and fuel samples to the cooperating laboratories in England; namely, the Asiatic Petroleum Co., the Anglo-American Oil Co., and the Anglo-Persian Oil Co.

As a result of this joint undertaking, the Society obtained the second paper at the afternoon session, presented by Dr. H. C. Dickinson in the absence of the foreign authors, C. H. Barton, C. H. Sprake, and R. Stansfield. This paper, entitled, Comparison of Antiknock Ratings Determined in Different Laboratories, reports the results of cooperative tests made in the laboratories of the three British oil companies and establishes tolerances of ratings determined with different equipment and men.

Discussion of the papers showed a keen interest in the topic of detonation, which will have its full significance when the recommendations of those studying it are released. It should be remembered that many problems are involved which need clarification before recommendations can be made authoritatively. Many of the by-products of the study will be of value in themselves, bringing about a better understanding of the refining, blending, storing and marketing of fuels and a clearer conception of engine design in its relation to fuel characteristics; that is, combustion-chamber design, ignition in all its elements, carbureter and fuel-system design, operation and servicing.

Bearing Lubrication and Carburetion

Papers on Bearing Friction-Coefficient Research and Downdraft Carburetion Presented and Discussed

IN THE absence of the author at the Engine Session on Wednesday afternoon, the presentation of Louis Illmer's paper on Friction-Coefficient Research devolved upon T. P. Stewart, automotive research engineer of the Vacuum Oil Co.; and E. H. Shepard's paper on Downdraft Carburetion was read by T. J. Litle, who is now connected with the Holley Carburetor Co. This session, held in the Italian Garden of the Book-Cadillac simultaneously with the Foundry Economics and Production Session in the Crystal Room, was attended by more than 150 members and guests, and L. P. Kalb, of the Continental Motors Corp., presided.

Think Formulas Complicate Subject

Mr. Stewart summarized Mr. Illmer's paper, which was published in THE JOURNAL for January, p. 67. The paper gave a comprehensive survey of representative experimental research directed toward perfect-oil-film lubrication, and with this as a basis, the author made an endeavor to correlate empirically, by means of analytical research, the experimental results obtained by different investigators and to establish certain underlying principles common to all such tests in which the frictional resistance depends primarily upon fluid shear. The conclusions arrived at were predicated upon a rather wide range of reported determinations, including most of the relevant tests that have found their way into friction literature during the last 50 years. In piecing together this accumulated experience, along the lines suggested some years ago by Prof. M. D. Hersey, a reason-

ably reliable but relatively simple method for predetermining certain kinds of friction losses was deduced, according to the author.

Commenting on the paper in discussion, Dr. H. C. Dickinson, of the Bureau of Standards, expressed the opinion that a great deal of very careful work and study had been done in preparing this paper but that, in his use of so many empirical formulas, the author had tended to bring chaos out of order instead of order out of chaos. George A. Round, of the Vacuum Oil Co., and Prof. A. E. Norton, of Harvard University, also spoke in discussion of the paper and agreed with Dr. Dickinson's comments.

Discussion on Cold Carburetion

Mr. Litle, after reading Mr. Shepard's paper, which is printed on p. 153 of this issue, answered many of the questions propounded in the discussion. This paper sketches the reasons for the present adoption of this type of carbureter on some of the latest car models, its flow characteristics following the engine requirements at all speeds for wide-open-throttle operation and the carbureter giving a 10 to 13½-per cent increase in horsepower over the entire range of engine speeds.

L. H. Grisell, of the Scripps Motor Co., gave prepared discussion illustrating the uses of downdraft carburetion in the marine field, showing how it tends to produce more power, greater flexibility, better economy and assures more safety from fire hazard.

F. C. Mock, of the Bendix Aviation Corp., added to the discussion by tracing the history of downdraft carburetion from its inception in 1888 by William Maybach to its present usage, and added that it does not entirely solve the problems with which we are at present confronted.

Mr. Litle then answered questions from the floor regarding cold starting, correct carburetion under engine-idling condition, heat on the manifold, fire hazard, horizontal carburetion, and atomization and vaporization and other phases of the subject.

New Car Models and Shows

Reeves at General Session Credits Engineers with Creating Public Interest in New Models

THIS is the year of the engineers, said Alfred Reeves, general manager of the National Automobile Chamber of Commerce, speaking at the General Session on Wednesday evening. "In the early days he was the most important factor in the company, when the chief problem was to make a car that would run and stay running. Then the production men had their innings; men who could make cars fast enough and cheap enough to supply the needed broadening public demand.

"Last year the sales department was the dominating influence because production temporarily exceeded demand and new markets had to be found. Sales will continue to be a problem, not alone in the automobile industry, but in every other industry in which mass production has brought record production.

Engineers Create Show Interest

"This year, however, the engineers will be at the throttle, turning on the steam which will enable the industry to make a successful run in the coming 12 months.

"Sound management, financial wisdom and judgment of markets are always essential, but the better design of cars with better performance, coupled with attractive styles, promises to be the chief stimulus of markets during the current year.

"The New York Automobile Show was the kick-off for 1930 business," continued Mr. Reeves, "and astonished not alone our own industry but other industrial leaders by the extraordinary attendance and sales. Reports indicate that shows in other sections of the Country, including the fine affair now running in Detroit, are furnishing a similar gratifying interest.

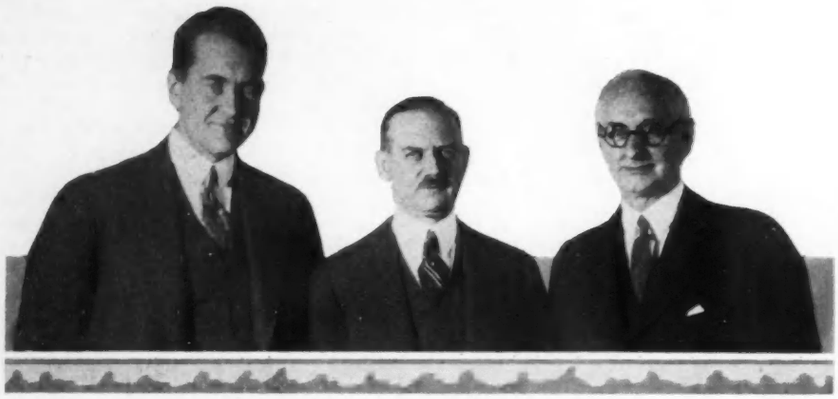
"People came to the shows this year because new cars and new improvements are being offered. Greater endurance, increased efficiency and more economy are the keynotes. To the engineer must go the credit for the extraordinary reduction in operating costs which are being reported by independent surveys.

"The greatest thing about our automobile leaders is their readiness to acknowledge a mistake and their promptness to learn from it. For that reason, many changes in advertising, production and selling plans will be made this year.

THOSE WHO TOOK A PROMINENT PART IN THE ENGINE SESSION

(Top) E. H. Shepard, Author of a Paper on Downdraft Carburetion, Which Was Presented by T. J. Litle; L. P. Kalb, of the Continental Motors Corp., Chairman; and T. P. Stewart, of the Vacuum Oil Co., Who Read Louis Illmer's Paper on Friction-Coefficient Research

(Bottom) Dr. H. C. Dickinson, of the Bureau of Standards; George A. Round, of the Vacuum Oil Co.; and Prof. A. E. Norton, of Harvard University, Who Discussed the Subjects



NOTABLES AT THE GENERAL SESSION

President E. P. Warner, of the Society; Alfred Reeves, General Manager of the National Automobile Chamber of Commerce, Who Made the Address of the Evening, on What 1930 Offers to the Motor Industry; and Past-President Strickland, Who Presided at the Session

"We must continue to maintain advertising; to strengthen selling organizations here and abroad; to encourage showings of our products, whenever a buying atmosphere can be created; to work for broadening markets both here and abroad, and, in fact, continue the vigorous merchandising methods that have put our industry in first place.

"Let us not be too anxious to show red lights; to put brakes on everything we have been doing in the past. Rather let us keep the green lights burning as an order to 'go,' with occasional flashes of the yellow light to remind us of caution.

"All this must be done with an increasing recognition of the needs of our distributing organization of 54,000 dealers, who met with unusual problems last fall because the readjustment period came at a time when they were carrying heavy stocks.

Balanced Production Important

"Although it is difficult in a style business, or one in which improvements must be promptly adopted, every effort should be made to secure balanced production for the benefit of our employes and our dealers. President Macauley of the N. A. C. C. suggests that production be as nearly as possible at the rate of one-twelfth each month, which might cost a little more to carry stocks, but which would be somewhat offset by evenness of production and employment.

"We must maintain the present cooperative spirit among the leaders with the fine ethics that have governed the keen competition which keeps the industry on its toes. We cannot overlook the need for expanding our work in the field of uniform traffic, accident prevention and highway improvement; in securing fair rates and efficient methods in railroad and steamship transportation; in a continued program for highway construction, watching to see that there is honest expenditure of the funds. We must also campaign for motor-vehicle laws and taxation plans that will not be oppressive; negotiate fair insurance rates for the buyers of our products.

When to Change Models

"We all agree that there are now too many passenger-car models; 725 are listed, so there is certain to be a receptive mind for the suggestion that we have less frequent model changes. Opponents, however, insist that competition will require the bringing out of a new model when the old one ceases to sell easily, or when a competitor offers a better product, either from a style or mechanical viewpoint.

"Manufacturers who favor changing models at New York show time point to the record business that always comes with the spring weather and which probably always will be heavier than at any other time of the year. They insist that introducing new models in January gives nine months of good weather for sale, with a flat period only at the end of the year, when bad weather always has slowed motor-car sales.

The Value of Shows

"Now and then we hear questions about the value of shows, but these are effectively answered when we review the extraordinary attendance of the public at New York City and in other cities where shows are held. The creation of buying atmosphere, the all-round publicity, the opportunity to increase confidence of dealers and selling organizations will continue to be of great value and have made our shows the envy of every other industry in the Country.

"Shows may disturb factory plans for a month, but they certainly develop a greater business during the six months following," continued Mr. Reeves. "In truth, it is not for the manufacturers or the dealers to rule on the holding of automobile shows. The real answer will come from the public. When, as at present, hundreds of thousands attend the shows to see the products of our industry, the shows should be continued and made as attractive as possible. When the public does not attend, it will be time enough to call for a substitute.

"Our manufacturers have voted that dealers hold their own local shows, and that National shows be given in New York City and Chicago. The National show is held in New York City because there are more than 10,000,000 people within 50 miles of it, which is more than the combined population of Arizona, Colorado, Delaware, Idaho, Maine, Maryland, Nevada, New Hampshire, New Mexico, North Dakota, Oregon, Rhode Island, Utah, Vermont and Wyoming.

"Dealers attend the New York exhibition in greater numbers than anywhere else, our increasing foreign trade is helped and there is opportunity for bankers and leaders of other industries to obtain a greater appreciation of the motor industry and its value to American prosperity."

In conclusion, Mr. Reeves said:

"Let us make the most of everything we have to broaden our markets. Let us not 'rock the boat' that carries our business plans for 1930. Let us view with disfavor the man who thinks it smart to repeat unfavorable and generally unfounded rumors about persons or companies in the motor-vehicle industry or in general business. Facts are safe guides, but rumors are generally misleading and opposed to the high standards that now dominate American business."

Mr. Reeves' talk was followed by an open forum during which he answered questions relating to 1930 prospects.

Herbert Chase contributed a brilliant little skit on "Atrocities of the 1930 Show."

W. R. Strickland, the retiring President of the Society, was in the chair.

Transport Vehicle Problems

Pierre Schon Presents a Three-Part Paper Dealing with Matters of Vital Importance

ONE OF the most interesting technical sessions of the meeting was that on Thursday afternoon at which Pierre Schon, of the General Motors Truck Co., presented his paper on The Trend of Weight and Size in the Development of

Motor-Trucks and Motorcoaches. About 250 members and guests of the Society followed the presentation of the paper with great interest, as many of the matters dealt with are of vital current importance to motor-vehicle manufacturers and operators.

Mr. Schon divided his paper into three general parts, each dealing with a particular phase of the general subject.

After referring briefly to the recent activities of National organizations such as the Society and the American Electrical Railway Association toward establishing standards for motorcoaches and motor-trucks, Mr. Schon indicated that in leading up to his main subject it was necessary to take into consideration the revolutionary changes that have occurred in the design of motor-trucks and motor-truck powerplants during the past five years. Some of the more notable change-overs he mentioned were the discarding of the four-cylinder engine for the six, the introduction of crankshaft counterweights and torsion balancers, better manifolding and carburetion and the tendency toward higher-compression engines. He pointed out that, in looking back at the 1925 and 1926 models, the improvements made in motor-truck design during the last three years are more numerous and revolutionary than were the combined changes made in them during the preceding 15 years.

He indicated that similar advancements have been made in chassis parts such as clutches, transmissions, steering-gears, frames, axles and wheels, making chronic failures in service a rare exception under normal usage.

Truck Balloon Tires Change Conditions

With these changes go the tendency to adopt balloon tires on motor-trucks, following the almost sudden change from solid tires to pneumatics and the effect they have had on chassis design. Mr. Schon pointed out that with the previous slower-moving solid-tire-equipped vehicles a few thousand pounds of excess weight would not seriously interfere with the economical operation of the vehicle, but that the general adoption of the pneumatic tire presents a different problem, as excess weight or overloading of a pneumatic tire more directly affects the tire cost per mile than does the overloading of solid tires, and that where pneumatic tires are used the carrying capacity per pound of dead weight is greatly increased without endangering the life of the vehicle. One explanation for this lies in the reduction in vibratory stresses in the load-carrying members due to better cushioning, and decreasing the liability of crystallization in the metal structure.

The paper then led into the question of what constitutes an overload, regarding which Mr. Schon stated that "the engineer designs a truck to carry 1 ton, the salesman sells it as a 2-ton truck, and the operator loads it with 3 tons." He attributed the present condition to the customary rating of a motor-truck by net pay-load capacity and the large variety of chassis weights, together with the indefinite and uncontrollable range of body weights. The paper was accompanied by a chart of the minimum and maximum chassis weights under various pay-load capacities ranging from ½ to 5 tons that showed a variation in some cases of nearly 100 per cent in chassis weight for the rated capacities.

Straight Truck Load-Rating Advocated

In discussing this phase of the paper, Mr. Schon indicated that the haulage of freight by motor-truck is the only type of transportation in which overloading is countenanced; railroads, steamship lines and such transportation groups refusing to accept loadings beyond the marked capacity of the transporting vehicle. The system or formula for straight rating of motor-trucks is, according to Mr. Schon, receiving greater attention from the motor-truck manufacturers and is a step in advance in curing the evil of abnormal overloading.

The straight rating of a truck chassis starts with the designing engineer in laying out a coordinated chassis design capable of performing for 100,000 miles or more under a given predetermined gross weight, the carrying capacity of front and rear axles being determinable from laboratory tests and past performance. Adding the carrying capacity of the front and rear axles will give the total gross weight for the contemplated design of vehicle of a certain carrying capacity. Selection of the correct tires for the vehicle then becomes a relatively simple matter, as the tire manufacturers have established maximum-load values for the tires. Mr. Schon pointed out that a given chassis design may be given several gross ratings by using tires of smaller size than are required for the maximum total gross weight. In cases where operators insist on using smaller tires than are recommended by the manufacturer, the straight-rating policy will make it necessary for the vehicle salesman to warn the buyer that he is taking a risk of abnormal cost per tire-mile.

The actual pay-load can be established only after weights of cab, body and special equipment have been definitely established.

Standardization of Load Spaces

In Part 2 of his paper Mr. Schon referred to standardization of the distance from the back of the cab to the center of the rear axle and to the cab dimensions adopted by the Society a number of years ago. These standards, he said, had not been used mainly because of the great variance of front-axle location and the large number of over-all body lengths in use. Because of this lack of uniform practice, the determining of wheelbase and load-space dimensions has been left to individual designing engineers, who have been more or less influenced by their sales organizations toward increasing wheelbase dimensions that will permit of mounting bodies a little larger than those of their competitors.

Mr. Schon indicated that body manufacturers throughout the Country are anxious to have greater standardiza-

PRINCIPAL PARTICIPANTS IN THE TRANSPORTATION CONFERENCE

B. B. Bachman, of the Autocar Co., Presided, and Pierre Schon, of the General Motors Truck Co., Presented the Only Paper, Which Comprised Three Parts Covering the Trend in Size and Weight of Motor-Trucks and Motorcoaches

tion of the most important dimension involved, which is the distance from the back of cab to the center line of the rear axle, so that bodies of a size that would be applicable to any make of truck could be built in large quantities. From the operators' point of view the lack of interchangeability of bodies on chassis presents a serious problem in many cases, because many special-purpose bodies may outlast two or even three chassis. Also, because of lack of standardization, the author stated that many large industrial groups are tending to standardize truck requirements for their particular field of work and this is slowly forcing the truck manufacturers into the building of chassis to meet the requirements and standards of each of these vocational groups, the result being unnecessary duplication and variety and consequent uneconomical manufacture.

This part of the paper was illustrated with charts and a tabulation of comparative load-space dimensions that showed bodies of 97 lengths built by six truck manufacturers in 1929.

Continuing, Mr. Schon mentioned that what had been said about load-space dimensions from cab to center line of the rear axle applies also to widths of frame. An accompanying table showed the large variations in frame width in six makes of truck.

Many Body Variations with Eight Load-Spacings

A table was also presented to show the result of a careful study of the possibility of standardizing load-space dimensions from cab to center line of the rear axle ranging from 39 in. for the small delivery type of body 6 ft. long up to 135 in. for the 21-ft. moving-van body. In setting up recommendations for such standard load-space dimensions for all normal cases, a practical tolerance of plus or minus 1 in. in the rear-axle location should not be exceeded, said the speaker, although in a few isolated cases chassis might have to be furnished for bodies longer than 22 ft. The table accompanying the paper provides an entire range of practical body-lengths from 5 to 22 ft. mounted on only eight standard load-space dimensions from the cab to the center line of the rear axle without any danger of abnormal load distribution. This gives 25 different body lengths without a greater size-variation than multiples of 6 in. These multiples can be divided into variations of from 1 to 5 in., making it possible to mount more than 100 different body lengths without abnormal load distribution on any one.

An interesting feature of this study is that two separate investigations of the subject, one by the American Petroleum Institute on the Pacific Coast and another made in Michigan, both based on taking into consideration Nation-wide use in all vocations, are very nearly the same in their results. The paper urged that the time has arrived when the Standards Committee of the Society should take up this matter and establish a schedule of standard dimensions as an S.A.E. Recommended Practice.

Motor-Vehicle Legislation and Taxation

In part 3 of his paper Mr. Schon stated that one of the most serious problems confronting designing engineers, truck manufacturers and operators which is becoming more intricate every year is the great variety of State rulings and local restrictions concerning vehicle size and weight and the taxation of commercial motor-vehicles, more than 2500 amendments having been presented to the legislatures in 41 States during 1929. This situation was illustrated by a few typical examples, some of which border on the ridiculous, as illustrated by one in which a bill was proposed against the use of spray-guns for painting motor-vehicles.

The difficulty in promoting long-distance hauling by motor-trucks in foreign countries due to frontier regulations was likened to the difficulties of moving freight freely from one State into another because of the differences in their motor-vehicle regulations. The tabulation of regulations in various States was interesting, showing that in only two adjacent States, California and Arizona, is similarly in regulations found.

Mr. Schon said that operators are subject to attack from various angles and that a variety of restrictions may be made into laws by any State, causing premature obsolescence of commercial vehicles of large aggregate value. In some States it is almost impossible, he said, for operators to plan the replacing of obsolete equipment or the purchase of additional vehicles because of uncertainty as to how changes in local restrictions may affect these vehicles within their profitable service life. The problems of the designing engineer and the manufacturers are multiplied when attempting to incorporate in their designs all required factors to permit of operating the vehicle under the existing laws in different States. Speed regulations were cited as an illustration, it being stated that with the development of modern braking systems and brake design, the operation of pneumatic-tired trucks is relatively safer than is that of passenger-cars.

Concerted Action on Regulation Needed

In a summation of this phase of his paper, Mr. Schon stated that, unless the efforts of manufacturers' and operators' associations are coordinated in the future, little relief from the present situation is in prospect. The work of the Motor Vehicle Conference Committee, in cooperation with the National Automobile Chamber of Commerce, and of the National Conference on Street and Highway Safety, was cited as examples of progressive thought toward uniform motor-vehicle legislation and regulation. He also referred to the classification of roads in the program of the National Conference on Street and Highway Safety, its relation to the determination of gross vehicle weights and the possibility, under this classification, of the operators of heavy-duty trucks determining definitely the type of equipment needed for certain routes, without fear of having outlaw equipment on hand by reason of regulation or legislation after its purchase. The various weight regulations for four-wheel trucks, four-wheel trailers and six-wheel vehicles were mentioned, some inconsistencies that exist in the values given in the code being pointed out.

Discussing pneumatic versus solid tires on commercial vehicles, Mr. Schon referred to data developed from road-impact tests made by the Bureau of Public Roads as indicating that pneumatic tires cannot cause any serious damage to well-constructed pavements. He used his analysis of these tests to indicate that properly tired, modern, high-speed motor-trucks are not the destructive agency they have been claimed to be.

The remainder of the paper dealt with problems of the vehicle manufacturer and operators arising from the taxation systems in various States and suggested a uniform method of fixing the gasoline taxes.

Discussion following the paper indicated that possibly the greatest problem of the motor-truck manufacturer is the introduction of the balloon type of tire on motor-trucks under the existing laws or regulations governing maximum width in various States. It was urged that the Society take up this and other engineering problems touched on in Mr. Schon's paper for study and the recommendation of standards that will eventually lead to solution of the present troubles of the truck manufac-

turers and operators in long-distance hauling and their relation to State regulation and legislation. The discussion also indicated that, although legislation and taxation have an important bearing on the problems reviewed by Mr. Schon, the Society in taking any action on these problems as a National body should confine itself to the engineering phases and avoid entering the field of legislation and taxation matters, which more properly should be dealt with by organizations such as the National Automobile Chamber of Commerce.

Two Activities Elect Nominating Committees

Immediately preceding the presentation of Mr. Schon's paper, Chairman Bachman convened the session as a business meeting of the Transportation and Maintenance Activity and asked F. C. Horner, Vice-President of this Professional Activity, to preside. Mr. Horner quoted from Section B-26 of the By-laws providing for the election of a Nominating Committee of the Activity for the purpose of nominating a Vice-President of the Activity for the year following. On motions duly seconded the following were elected to serve on this committee: Donald Blanchard, E. W. Templin, Pierre Schon and H. W. Middleworth.

To provide against the possible declination by some of the members elected or their inability to serve on this Committee, the following, on motions duly seconded, were elected to serve as alternates: A. J. Scaife and T. B. Preble.

As the Transportation Conference Session of the Annual Meeting was sponsored jointly by the Transportation and Maintenance Activity and the Motorcoach and Motor-Truck Activity, a business meeting of the latter Activity was also declared by Chairman Bachman, who surrendered the chair to A. J. Scaife, Vice-President of the Motorcoach and Motor-Truck Activity. On motions duly seconded the following were elected to serve as the Nominating Committee for this Activity, to nominate a Vice-President of the Activity for next year: G. A. Green, A. F. Masury, C. F. Magoffin and B. B. Bachman.

Ferdinand Jehle and C. A. Peirce were also elected, on motion duly seconded, to serve as alternates on this Committee in the case of declinations by any of the first four named.

Riding-Comfort Investigations

Valuable Data on Fatigue, Vibration and Shock-Absorbers Presented and Extensively Discussed

ALL WHO attended Friday forenoon Riding-Comfort Session on Jan. 24, the last day of the Annual Meeting, will remember it as a vitally important session. The subject of riding comfort is of such broad appeal that the session was well attended; and the three papers presented contained such valuable data that the ensuing discussion could have extended almost indefinitely had time been available.

The chairman, W. R. Griswold, of the Packard Motor Car Co., said that until a comparatively recent date the methods employed to judge and measure riding-qualities have been at best rather unscientific; therefore the Society sponsored a committee to undertake research to measure objectively the amount of discomfort or fatigue experienced by a passenger in the course of an automobile ride, with a view to eliminating discomfort and ultimately securing a more pleasurable ride. He introduced, as the first speaker of the morning, Dr. Fred A. Moss, head of the Department of Psychology of George Washington University, who is in charge of this research work.

Dr. Moss characterized the experiments that have been in progress as an attempt to use the human body as an instrument to measure the fatigue caused by an automobile ride and to predict therefrom the possible effects of the various types of spring suspension, shock-absorber and other comfort-giving components.

Two reasons given by Dr. Moss for initially approaching the problem from the physiological standpoint are that (*a*) it is definitely known that fatigue is a physiological phenomenon and (*b*) if the physiological changes are sufficiently marked to be measured, physiological tests are quite definite and quantitative.

According to Dr. Moss, the changes in the human body are a good index of relative comfort; if the normal reactions are known before a test, in the case of any individual or group of individuals, similar measurements made at the end of, say, 300 miles should show an appreciable difference. This difference, which he claims is a direct measure of comfort, may be determined in two ways: first, by measuring physical fatigue; second, by measuring nervous fatigue. Methods of making these determinations were described in the Automotive Research section of THE JOURNAL for January, p. 99.

Conclusions Reached to Date

Dr. Moss summarized his conclusions, to date, as follows:

(1) Muscular fatigue, produced by strenuous exercise over a short period of time, can be very well measured by physiological tests of blood, metabolism, and urine.

(2) Of the physiological tests applicable to the fatigue of automobile riding, basal metabolism and carbon-dioxide combining-power of the blood are most reliable.

(3) The fatigue from automobile riding is probably more nerve fatigue than muscle fatigue.

(4) Equilibrium, as measured by two differently recording wabblemeters, is markedly disturbed by long automobile riding. Other tests for nerve fatigue that have shown some differentiating value are number checking and mental multiplication.

(5) In fatigue produced over a long period of time, as by riding, fatigue counteractants, such as adrenalin, poured forth into the body seem to reduce the physiological manifestations.

(6) A score card for oral reports of the riders gives additional information valuable in judging the fatigue from riding. Such a score card is being standardized for automobile road-tests.

Improvements Planned for Further Study

Plans for future development and study include (*a*) further improvement and standardization of the two types of wabblemeter; (*b*) further standardization of the basal-metabolism test, with particular attention to the establishing of "normal" for different times of day; (*c*) improvement of the score card for oral report of discomfort; and (*d*) experiments with other new measuring devices.

Regarding improvement of the wabblemeters, Dr. Moss stated that the standards for interpretation of results will involve the establishment of norms and corrections for age and sex of the individual being tested, atmospheric conditions of temperature and pressure, and time of day, as equilibrium is better in the morning than later in the day. These standards for interpretation will make it possible to use the machines on road tests without an extra amount of preliminary experimenting with the subjects tested.

When the machines have been perfected and the methods standardized, it is proposed, using the same subjects over the same road, to measure the differentiation in wabble between rides of 100, 200, 300, 400 and 500 miles. Then, over the same road and under the same conditions of driving, the test differentiation will be made between different types of car, spring, shock-absorbers and cushions.

Investigation To Be Extended

In conclusion, Dr. Moss stated that his further experimentation will include, (*a*) investigation and application of tests to his own "calibrated" subjects in the laboratory, (*b*) study of tests on a large number of taxicab and motorcoach drivers, and (*c*) application of the results with various outside groups of riders and test persons.

The investigation was spoken of re-

peatedly in the discussion of the paper as extraordinarily important and exceedingly valuable. The tenor of the discussion indicated that much work remains to be done, and a number of suggestions for future tests were offered. Past-President W. R. Strickland reminded those present that the work thus far has been carried on with voluntary contributions and that further progress in the work will have to be supported by those most interested.

Engine-Mounting and Shock-Absorbers

Earl H. Smith, assistant chief engineer of the Olds Motor Works, introduced as the next speaker, presented his paper on Elimination of Chassis Vibration, which is published in this issue of THE JOURNAL, beginning on p. 156. At the conclusion of Mr. Smith's presentation, Chairman Griswold called attention to the fact that the author had very clearly brought out an important factor in connection with rubber mounting of an engine; namely, that the frame must be redesigned to avoid some of the troubles from vibration which otherwise are very likely to occur.

Prof. J. M. Nickelsen, of the University of Michigan, presented the third paper, which dealt with shock-absorbers and their action on the car. Stating that the trend in shock-absorbers has been from the strap-type snubber to the one-way hydraulic shock-absorber and lately to the two-way hydraulic shock-absorber, Professor Nickelsen devoted most of the time at his disposal to a consideration of the last-mentioned device. Tore Franzen, of the Chrysler Corp., presented some interesting prepared discussion of Professor Nickelsen's paper, and a number of others present took part in the open discussion, revealing a wide range of opinion.

Airplane-Engine Dependability

Various Phases Discussed by Commander Wilson—Upson Analyzes Metalclad Airship Possibilities

THE Aeronautic Session of the Annual Meeting was held before one of the largest gatherings attending any of the sessions in the last several years. More than 350 aeronautic and other engineers gathered to hear the paper on the Importance of Dependability of Aircraft Engines, by Commander E. E. Wilson, formerly one of the leading engine experts of the United States Navy, and now general manager of the Hamilton Standard Propeller Co., of Pittsburgh, and the paper on The Metalclad Airship, by Ralph H. Upson, its designer.

RIDING-COMFORT SESSION CHAIRMAN, SPEAKERS AND DISCUSSERS

(Top) W. R. Griswold, of the Packard Motor Car Co., Who Presided; Dr. Fred A. Moss, of George Washington University, Who Made a Progress Report on Investigations Using the Human Body as a Yardstick; and Earl H. Smith, of the Olds Motor Works, Who Described the Development of Rubber Engine-Mountings

(Bottom) Prof. J. M. Nichelsen, of the University of Michigan, Who Showed a Series of Charts of Axle and Car-Body Movements as Affected by Shock-Absorbers; F. E. Cornell, of the Houdaille-Hershey Corp., and Tore Franzen, of the Chrysler Corp., Who Discussed the Subject

Carl B. Fritsche, of the Detroit Aircraft Corp. and its subsidiary, the Aircraft Development Co., which built the ZMC-2 metalclad airship, acted as Chairman.

Different Engine Types Compared

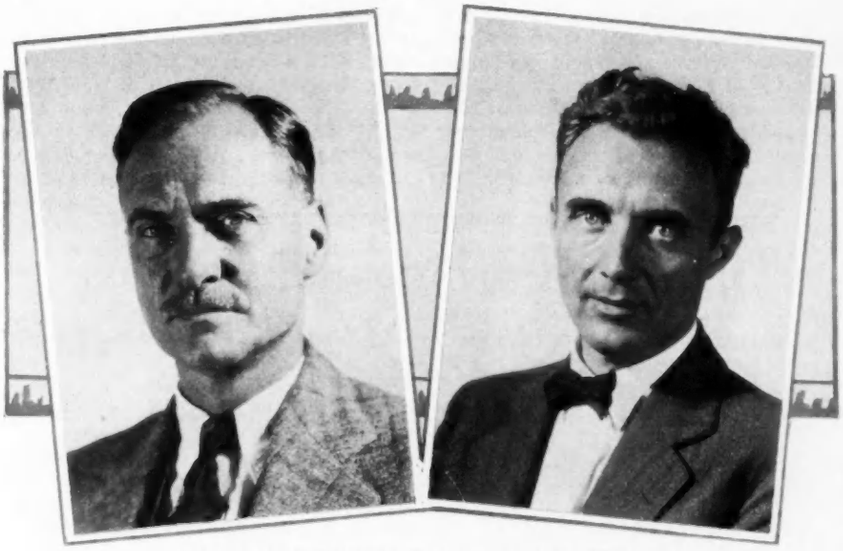
As Commander Wilson was ill and confined to his bed in Pittsburgh, he was unable to present his paper, which was read by Edward P. Warner. The paper covered the subject of the dependability of the mechanism of aircraft engines and the dependability of the personnel responsible for their operation. It dealt with the comparative dependability of direct-cooled engines and engines cooled by chemicals or water. The author discussed the single-row radial engine, the in-line engine and V-type engines in the various classes of service in which they have been used. dependability of multiple-engine installations was also taken up, and the relative differences in the required dependability demanded by planes used in over-water flying and those used in over-land operation.

The resulting discussion by Capt. L. M. Woolson, of the Packard Motor Car Co.; Harold Caminez, of the Cadillac Motor Car Co., Detroit, and William M. Britton, of the Aero Service Co., of Los Angeles, expressed different opinions as to the dependability of the air-cooled versus the chemical or water-cooled engine, and the dependability of multi-engine versus single-engine installations.

Metalclad Airship Possibilities

Introducing Ralph H. Upson, the designer of the ZMC-2, as "the man who had the courage to wander outside the realms of the known and invade the realms of the unknown to develop a theoretical foundation for this experiment," Chairman Fritsche presented the second speaker of the evening.

Mr. Upson presented both sides of the controversy that has raged since the designing and completion of the metalclad ship, citing the alleged advantages and disadvantages which have been expressed by authorities and others throughout the Country. The possibility of further development of metalclad airships of larger capacity,



AERONAUTIC SESSION CHAIRMAN AND SPEAKER

C. B. Fritsche, of the Detroit Aircraft Corp., Presided, and Ralph Upson, Designer of the ZMC-2, Gave a Paper on the Metalclad Airship and Its Prospective Future

the limits of the size to which this type of construction can be carried, and the reasons therefor were presented.

Supplementing his talk by a series of slides showing various features of design and tables of figures on volume, length, diameter, skin thickness, maximum pressure, speed, weights and lift for various sizes of metalclad airships, Mr. Upson discussed the factors that enter into further development of this type of construction. The address was further supplemented by two reels of pictures showing some of the early stages of construction and also the first test flights made at Grosse Ile. The audience was extremely interested in the construction methods that have been necessary to accomplish the results desired, and in the test-flight results obtained since the delivery of the ZMC-2 to the Navy.

A short talk given by Captain Kepner, of the Army Air Group, who was the test pilot of the ZMC-2, was one of the high-lights of the session and showed the extreme care and extensive preparations which had been made both before and during the flight tests.

In concluding the meeting, Chairman Fritsche answered the question which has been in the minds of many throughout the Country, as to what the next move would be relative to further use of metalclad airships, by announcing the design of a 100-ton ship, to have a speed of 100 m.p.h., which is now in process, to provide a dirigible with something like 17 times the gross lift of the ZMC-2.

Keen Interest in Diesel Engines

Two Papers Presented by Leading Technical Authorities Are Provocative of Much Discussion

TWO PAPERS were presented at the Diesel-Engine Session, on the morning of Thursday, Jan. 23. These were Light-Weight Diesel-Engines, by O. D. Treiber, president of the Treiber Diesel Engine Corp.; and Combustion Chambers, Injection Pumps and Spray Valves of Solid-Injection Oil-Engines, by J. E. Wild, of the Robert Bosch Magneto Co., Inc. The session was well attended, and the discussion following the presentation of the papers was so lively that it could easily have been prolonged to fill an entire day instead of a single session, as was pointed out by A. J. Poole, of the Robert Bosch Magneto Co., who was chairman of the session.

In his opening remarks Chairman Poole stated that recent developments in Diesel engines and their applications have brought this type of engine very forcefully to the attention of the public, with the result that gasoline-engine engineers are now giving considerable thought to the subject. In this connection he told of a recent newspaper account of an automobile that made a trip of 188 miles on 5 gal. of oil, that is, an average of more than 37 miles per gal. of fuel oil costing 8 cents per gal., thus making the cost for fuel less than ¼ cent per mile. Accordingly, said Chairman Poole, the operator of a fleet of 50 or more motorcoaches or motortrucks, with an operating cost of about 2 cents per mile for gasoline, would certainly feel the need for investigating the possibility of using Diesel engines if savings like those indicated by the newspaper report could be effected. Consequently, as he pointed out, the topics listed for discussion at the Diesel-Engine Session were of interest to the gasoline-engine engineer as well as to the Diesel engineer. This fact was well attested by the representative character of the attendance at the session and the wide range of interests of the men who took part in the discussion.

Treiber Discusses Development

Mr. Treiber, introduced by Chairman Poole as the foremost authority in this Country on the light-weight high-speed Diesel engine, stated that the Diesel engine existed for about 30 years with little development toward the light-weight engine. He discussed some of the factors contributing to the development of the light engines, chief among these being the Naval demand of some years ago for light-weight Diesel engines, interest in the possibility of Diesel-powered locomotives and the post-war need in Europe for economical engines for motorcoach and motortruck service. As reasonably light weight is demanded of engines for this last-named service, Mr. Treiber discussed, as the chief means for reducing the weight of a Diesel engine, the following: increase of rotative speed; use of higher-strength materials, more highly stressed; and increase of the mean effective pressure.

Regarding aircraft engines, Mr. Treiber said that Diesel engines weighing less than 2 lb. per hp., thus comparing favorably with gasoline engines for the same service, will be available in the not very distant future, with fuel consumption of about 0.37 lb. per b.-hp-hr. Such engines, however, are not suitable for motorcoach, motortruck or other commercial service, either stationary or mobile, and their cost is prohibitive for anything but air service.

Mechanical Features Discussed

Concerning types of light-weight Diesel-engines suitable for mobile service, the speaker pointed out that they must be produced at a cost approximating the cost of gasoline engines, a requirement that introduces a weight-limiting factor which is dependent upon foundry limitations. He stated that it is possible to produce Diesel engines weighing only about 15 per cent more than gasoline engines designed for similar service, and pointed out that this difference is to be expected because of the higher pressures used.

In conclusion, Mr. Treiber described and illustrated with lantern slides some of the mechanical details of engines developed by his company.

The discussion brought out that wear

of the upper part of the liner is greater than that of the lower part, and a soft ring will wear out a liner much faster than a hard one will; that clean oil is a necessity, and dirty fuel must be centrifuged or put through a separator to eliminate foreign matter; that something is to be said for the use of furnace oil for automotive purposes, or even oil of a much lower grade and consequently cheaper; that trouble in using the heavier oil can be avoided to a great extent by the exercise of a little extra care in operation; and that the difficulties of filtering the fuel oil deserve consideration.

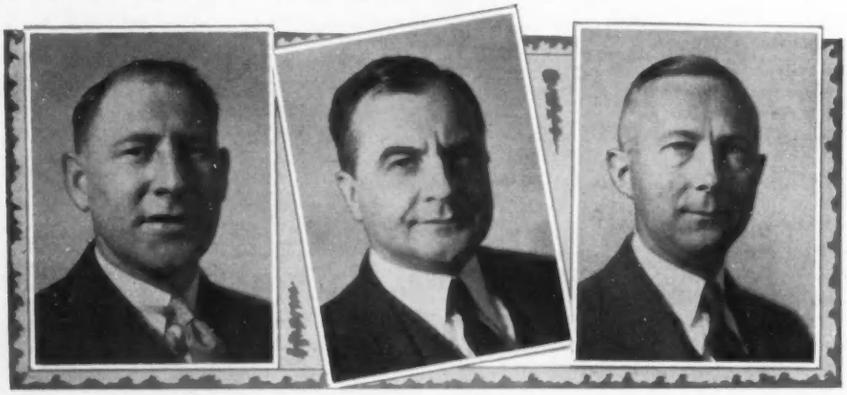
Wild Describes Injection Systems

Mr. Wild prefaced his paper by some remarks on the essential purpose for which the fuel-injection device is designed and went on to state that fundamentally there are two different types of solid-injection oil engines: namely, engines employing a precombustion chamber and engines using the direct-injection system. In the former, the fuel is injected into a chamber inserted in the cylinder-head and from there is blown into the main combustion space by the initial pressure caused by partial combustion of the fuel. Typical forms of precombustion chambers were shown in lantern slides and described by Mr. Wild.

In engines having direct injection, he said, the fuel is forced directly into the combustion space and mixed with the air, either by relying on the finely atomized spray of the nozzle or by the additional use of suitable air turbulence. Direct-injection engines he subdivided into those depending solely upon spray atomization, those which atomize the spray by air whirls, and those which have an auxiliary air-chamber. After a detailed consideration of these different types, he gave a description of the devices developed to introduce the fuel into the combustion-chamber, namely injection valves and injection pumps.

The discussion of Mr. Wild's paper brought out the fact that it is difficult to design an injection system that will perform with the desired degree of accuracy, as compromises are necessary, especially in the design of nozzles.

Just prior to the presentation of the two papers comprised in the morning's program, a business session of the Diesel-Engine Activity was held for the purpose of electing a Nominating Committee to nominate, before Sept. 1, 1930, a Vice-President to represent the Diesel-Engine Activity in 1931. A. J. Poole, J. H. Hunt, N. H. Gilman and C. D. Salisbury were elected to form the nominating committee, with Harte Cooke and L. F. Burger as alternates.



SPEAKERS AND CHAIRMAN OF THE DIESEL-ENGINE SESSION

O. D. Treiber, Who Gave a Paper on Light-Weight Diesel Engines; A. J. Poole, of the Robert Bosch Magneto Co., Chairman; and J. E. Wild, of the Robert Bosch Magneto Co., Who Described Solid-Oil Injection Devices

Tungsten Carbide and Casting

Precautions in Use of High-Speed Cutting-Tools Discussed —Green-Sand Casting Advocated

DESPITE a combination of unfortunate circumstances, the Foundry Economics and Production Session on Wednesday afternoon developed much valuable information and proved to be highly interesting, much lively discussion being brought out under the chairmanship of Leroy V. Cram, of the Chevrolet Motor Co.

Through oversight, the printers in New York City failed to deliver preprints of the main paper for the session in time to be received in Detroit prior to the convening of the session, and by unfortunate coincidence the author of the paper was unable to be present and his representative had no copy of his paper. To make it possible to present the paper at all, it was necessary to have the complete paper read over the long-distance telephone from the New York City office of the Society, received by the stenotype reporter for the meeting at the Book-Cadillac and then transcribed. As the work of transcribing was not completed by 2 p. m., the opening hour of the session, it was necessary to change the order of the papers and present the Donald Campbell paper on Relation of Foundry Practice and Engineering last on the program instead of first. The paper then was read by Mr. Beach, who is connected with the firm of Campbell, Wyant & Cannon.

Under the circumstances the session was opened with a business meeting of the Production Activity under the chairmanship of John Younger, for the election of members for the Activity Nominating Committee. The following were nominated, and after votes had been taken were elected unanimously: E. P. Blanchard, V. P. Rumely, L. A. Churgay and A. R. Fors, as members of the Nominating Committee; and J. M. Crawford and Alex Taub as alternates.

Carboloy Cutting-Tools Discussed

Resuming the chair for the balance of the session, Mr. Cram called upon A. K. Brumbaugh, of the White Motor Co., to present some notes on the experience of the White company with Carboloy tools. Mr. Brumbaugh pointed out that the recent trend in machine-tools has been to build them ruggedly so that heavy cuts can be taken without undue spring or chatter and that this is being done to destroy material that is of value, as the raw material that is converted into chips costs as much per pound as the material that is sold as finished product, about 70 per cent of the cost of a completed truck representing material, 10 per cent labor and 20 per cent overhead.

In a great many cases it is possible to reduce the amount of material removed in finishing a rough part and it might be profitable, suggested Mr. Brumbaugh, to concentrate on saving material as well as on saving time and labor cost. Many of the difficulties of finishing castings and forgings can be overcome, he believes, by the use of tungsten carbide or similar cutting-tools which are relatively unaffected by scale or slag and, within their limitations, will give a commercially true finished surface in one cut. To take advantage of the full possibilities of these tools, it is necessary to have earnest cooperation of the foundry and forge men in improving their processes so that the industry can secure uniform castings and forgings.

Probably the average loss on castings is about 12 per cent, including scrapping of parts that have been partly processed, and if 6 per cent of this loss can

be avoided, on a ratio of 7 to 1 for cost of material and labor, we shall save the equivalent of 40 per cent of the labor cost.

How Carboloy Tools Should Be Used

Much discussion of the use of tungsten-carbide tools and results obtained therefrom followed Mr. Brumbaugh's presentation. A high percentage of tool breakage was reported by S. F. Wilson, of the Hudson Motor Car Co., who also stated that considerable difficulty had been encountered in finding jobs for which the tools are adapted, but that now some of these troubles are beginning to be overcome and the tools have been successful on a number of operations, although there are still some operations on which the costs due to tool trouble have been greater than the saving effected.

In response Mr. Brumbaugh stated that tungsten carbide is a product that must be applied with special knowledge to realize its best advantages and that the makers of the product have now established the practice of giving closer and better technical study to the work that is being done. He said that the net result of the White Motor Co.'s experience with the tools has been satisfactory and that "carboloy has saved our lives on certain operations in the plant."

Howard Jones, shop engineer of the same company, stated that the plant had had no success with the tools on steels but is having very good success with them on cast iron, bronze and aluminum. On pistons, in which some sand is encountered, it can run as high as 50,000 pistons without noticeable wear of the tools. As many as 15,000 crankcases have been finished without any change in the tool, and success is also had in finishing flywheels, clutches, cast-steel housings and connecting-rods. The company calculates that the life of the tools is from 25 to 50 times that of high-speed steel tools. However, great care is necessary to use the tools only on work that they will do satisfactorily, and careful records are kept on the work. No success has been attained with the tools operating at the same speeds and feeds as with high-speed steel tools. If the speed is increased, the feed is reduced.

Sharpening Tools and Cutting Sharp Corners

Replying to Alex Taub, of the Chevrolet Motor Co., Mr. Jones stated that a 3-in. bore on crankcases is run at about 1250 r.p.m.; that connecting-rods are run at about 3000 r.p.m. and that good success is being had with a boring machine running at about 8000 r.p.m. The tungsten-carbide tools are used on both roughing and finishing work.

Numerous questions regarding the resharpening of the tools were asked by M. O. Teetor, of the Perfect Circle Co., which brought out from Mr. Jones that it is necessary to use extreme care in grinding the tools which usually are held by hand, with very light cuts of less than 0.0002 in. In the case of some tools, as those used for finishing the ring grooves in pistons, it is necessary to have the tools lapped, and for this purpose they are sent to the Detroit plant of the Carboloy Co., where special equipment for the purpose has been provided. Mr. Teetor enquired regarding the cutting of sharp right-angle corners, on which work it is necessary to hold a point on a tool; and Mr. Wilson stated that the Hudson company is having success with tungsten-carbide tools on a bronze job in which the part has 28 slots on the outside and a flange that must be faced down for about an inch into a sharp corner without a radius. No other tool would do the work.

CHIEF PARTICIPANTS IN FOUNDRY-ECONOMICS AND PRODUCTION SESSION

A. K. Brumbaugh, of the White Motor Co., Who Gave Some Notes on the Use of Tungsten-Carbide Tools; L. V. Cram, of the Chevrolet Motor Co., Who Presided; and E. W. Beach, of Campbell, Wyant & Cannon, Who Read Donald Campbell's Paper on Green-Sand Casting

Gives Facts about Carboloy

At this stage in the discussion Chairman Cram called upon W. G. R. Robbins, Detroit district manager of the Carboloy Co., who gave an excellent talk on the subject, giving a brief history of the development of tungsten carbide since the Cleveland Wire Works of the General Electric Co. began making tungsten wire for incandescent lamps in 1906, and its subsequent development for cutting-tools in Germany and America. He described the present process of its manufacture and emphatically stated that it is in no respect like steel, as it has entirely different physical properties. Its hardness is between that of the sapphire and the diamond, and at its present cost of $435 per lb. is about 400 times as expensive as carbon steel and about 1/400 the cost of diamonds on a poundage basis. It is not expected that these tools will displace the use of high-speed steel and Stellite, carbon steel and the diamond, but they have a definite place and can replace many diamond-cutting operations and also those that are performed now by carbon steel and show savings.

Carboloy cannot be welded to tool shanks because the coefficient of expansion and contraction of tungsten carbide is so small that contraction of the steel after welding breaks the carboloy, therefore the material is always brazed to the shank with copper in an atmosphere of hydrogen, because the Carboloy is ruined by a temperature of 1700 deg. fahr, in open air.

How Tools Should Be Ground

Regarding grinding of the tools, Mr. Robbins stated that the grinding-wheel manufacturers have within the last year produced wheels that will grind Carboloy with as much success as Stellite, high-grade steel or other tool materials. He cautioned against forcing the tool into the wheel, which only removes material from the wheel instead of the tungsten-carbide; the right practice in grinding tungsten carbide, either wet or dry, is to pass it across the face of the grinding-wheel as lightly as the tool can be touched to the wheel. He advised anyone who is adopting or experimenting with tools of this type to also make a study of the grinding of them, as "one might as well go out and cut his throat as to grind them like high-speed steel." Moreover, in nine cases out of ten, if a tungsten-carbide tool is used in a set-up for high-speed steel tools on cast iron, the result will be miserable failure because of excessive feed and the wrong speed. If the feed load is too great, the tool will break. The rule is to speed up the machine and cut the feed down, as the greater the speed is, the better the result, and tungsten carbide will cut at speeds unheard of in high-speed steel practice.

As the tungsten-carbide tools can cut through scale and hard spots, Mr. Rob-

bins stated that the limits on castings can be greatly reduced so as to save a great deal of waste material, and forgings can also be made to as close limits as can be got, letting the tools cut through the scale and without subsequent annealing. No one will have much success with the cutting of steels with tungsten-carbide tools, not because they cannot cut the steel faster than is now being done with any tools, but because operations on steels are not economical since too much material has to be removed and expensive tools are worn out before the job is completed. If the limits that were being maintained on the piece were so small that one cut could be taken to finish the job, the cutting of steel would be economical; however, the cutting of steel is not economical because the machine-tool is not sufficiently rigid and should have more power and chucking ability than for cast iron. Success is being had on some steel jobs in a multiple set-up by a manufacturer who had confidence enough in the use of tungsten-carbide to completeiy redesign his machine-tool for the purpose.

It may be easy to change from failure to success with the tools; for instance, changing the angle on the top of the tool ½ deg. made the difference between double production and zero in one case. Although the material can cut through scale and hard spots at greater speeds than are being used with other tools, it cannot drill through hard spots and cannot be used to ream a hard hole unless sufficient backing for the tool can be obtained.

Manufacturers who are contemplating trying out these tools were strongly recommended by Mr. Robbins to use them first on real production jobs that are simple instead of trying the tool on the most difficult job in the plant, because tungsten-carbide is more of a production tool than a cure-all for evil; and, after attaining success on the simpler work, knowledge gained in the use of the tool will enable more difficult work to be undertaken. For this reason the makers of the material are concentrating their efforts on bronze, brass, aluminum, cast iron, hard rubber and bakelite.

Green-Sand Casting

Chairman Cram drew a very human-interest picture of the firm of Campbell, Wyant & Cannon in introducing the subject of the paper by Mr. Campbell, and stated that the working of metals is one of the oldest arts; Noah probably used cast corners in the ark, and the situation in the casting of metals did not change materially from Noah's day until after the advent of the automobile. Sometime within recent years some bright purchasing agent or factory manager thought castings could be bought better by the piece than by the pound, and this has taken a lot of the mystery out of the making of castings because the foundry men began to recognize that foundry practice is an economic function. Chairman Cram referred to the three members of Mr. Campbell's foundry firm as the hardest kind of fighters among themselves in attacking a difficult problem, and as a combination that is extraordinarily hard to fight as a unit.

After Mr. Beach presented the Campbell paper, which is published in this issue of THE JOURNAL beginning on p. 177, the discussion on it developed opposed views between Chairman Cram and Mr. Taub, both of the Chevrolet Motor Co., as to the relative economy of producing castings by the green-sand and the dry-sand processes, Mr. Taub being an advocate of the former and Mr. Cram of the latter method. Mr. Cram regretted the absence of Arnold Lens, of the Chevrolet company's foundry in Saginaw, Mich., and also of Mr. Campbell from the session, which thereby missed a "lively dog fight" on this subject. The object of the Chevrolet company is to get the greatest possible value per dollar in its engines and cars; and Mr. Cram expressed his conviction that Mr. Lens could give this value in castings. The Chevrolet six-cylinder block, he said, represents thousands of hours of intensive study in the engineering, foundry and manufacturing divisions; some major changes, so far as stresses were concerned, were made to accommodate and simplify the foundry practice. A study was made about two years ago of the whole green-sand subject and the method was dropped in the company's own foundry.

Mr. Taub acknowledged Mr. Lens's ability to produce castings economically but maintained that the green-sand method is one that all should take into consideration, and explained that there are some engineering phases in casting that have not been considered. To illustrate, he sketched on the blackboard a three-bearing crankcase as cast by the green-sand method, as contrasted with the dry-sand process. Rigid bearing supports are very important and box-section supports can be obtained by the green-sand method without extra cost, which cannot be done by the dry-sand method.

Within the last six years, probably 25 per cent of the total dry-sand cores used for castings in the Chevrolet cars have been abandoned, according to Chairman Cram, but where the company shall stop on this elimination will depend on how much progress the foundry can make in its methods and how much ingenuity the engineering department can express in its design. However, he said he agrees with Arnold Lens that in their own organization more can be done for a dollar by the judicious use of dry sand, particularly in the inside of crankcases, than with green sand. Coarseness or fineness of the sand play such an important part in what the final casting in the green sand measures and weighs that each individual piece must be considered, and no exponents of either method are going to use either green sand or dry sand exclusively.

Session on Front Drives

Participation of Five Past-Presidents in the Discussion Shows Interest in Reversed Design

INFORMALLY, the Friday afternoon session on front-wheel drives took on the aspect of a past-masters' meeting at a lodge, when five Past-Presidents of the Society, including President Strickland, who was just about to receive his past-master's jewel, took active part in the discussion of the subject. The list includes David Beecroft, who was president in 1921; T. J. Litle, Jr., 1926, who acted as chairman of the session; John H. Hunt, 1927, and William Guy Wall, 1928.

In opening this final session of the meeting, Chairman Litle said that the fact that cars have always been driven by the rear wheels does not prove that to be the best practice. He mentioned an early experience of his own when he proposed a pipe along the top of each car of a railroad train, with telescopic joints, to conduct the smoke to the rear end of the train. He found that the scheme had already been invented, but the railroads have not even yet adopted it.

Built Around the Universal-Joint

The first paper was given by W. J. Muller, chief engineer of the New Era Motors, on the mechanical questions of front-wheel drive. Mr. Muller said that the design of the Ruxton car really was built up around the Weiss universal-joint, which he says transmits absolutely uniform angular motion even at extreme wheel lock, whereas an ordinary Cardan joint, operating through an angle of 30 deg., transforms uniform rotation into rotation that fluctuates between 13 per cent below and 10 per cent above the speed of the driving shaft. The Weiss joint, he said, functions efficiently under indifferent lubricating conditions because of the rolling ball-contacts.

A parallel was drawn between rear-drive cars and pusher airplanes, on the

one hand, and front-drive cars and tractor airplanes on the other hand. Mr. Muller said that both airplane pilots and automobile-racing drivers had found a greater stability from the pulling drive than from the pushing drive. Shifting of weight to the rear wheels is said to be merely an academic question. On a 15-per cent grade the center of gravity shifts about 3 per cent of the wheelbase. Shifting of weight during acceleration is of the same order, about 3½ per cent for an acceleration of 3 ft. per sec. per sec.

Stabilizing the Front Wheels

One interesting experience was with the location of the outer universal-joints. It was first thought that these must be absolutely centered with the steering-knuckle pivots. When this was done, the steering was balanced so perfectly that a tendency of the front wheels to wander was observed. The remedy was found by moving the centers of the joints far enough from the axes of the pivots to create a slight drag.

Mr. Muller said that front-wheel driving has its advantages, and a trend toward front driving will come. While the Ruxton is an expensive car, he asserted that there is nothing inherently costly in the drive; in fact, a front-drive car can be built at lower cost than an equivalent rear-drive car.

In opening the discussion, Chairman Litle remarked on the rumors that the Ford Motor Co. is turning to front-wheel drives. This rumor was placed by W. T. Fishleigh, of the company most frequently mentioned in rumors, in the same class with other Ford stories, among them the news item that he had heard on the Pacific coast to the effect that the Ford company had been purchased by the Packard company.

Placing the center of gravity of the car as far forward as possible was said by Roscoe C. Hoffman, of Detroit to be a leading problem in front-wheel car design. V-type engines and special transmissions are possibilities. The secondary advantages of front-wheel drive he considers the most important, opening many possibilities in the way of beauty and novelty.

Front-axle conditions as to camber and related adjustments were said by Herbert C. Snow, of the Auburn Automobile Co., to be different, with the front-wheel drive, according to whether the car is coasting or being driven under power. Vertical or almost vertical placing of the steering-knuckle pivots has been found advisable.

Presidents' Opinions and Experiences

President Strickland foresaw some difficulty in teaching drivers the different control necessary with a front-drive car. This difficulty he compared to that resulting from the lack of standardization because of two arrangements of gearshifting.

Value per dollar was the test applied by Mr. Hunt, of the General Motors Corp. The only other reason for a change would be a public demand, and Mr. Hunt believes that at present only a few people will have the courage to buy a car of such radical design.

Chairman Litle reported that a long cross-country experience of his in driving a front-drive car was very intriguing. He confirmed the feeling of safety in taking curves at high speed, part of which he thought might be due to the low center of gravity of the front-drive car.

Colonel Wall remarked on the possibility that front driving might result in a greater alteration in the form of the automobile than any change that has been introduced in many years. Quiet gearing he mentioned as being more essential in a car of this type than in a car of conventional type.

Questions of tire wear were taken up by B. J. Lemon, of the United States Rubber Co., and J. E. Hale, of the Firestone Tire & Rubber Co. Neither was prepared to say that front driving would make a great difference in total tire wear, but Mr. Hale prophesied disappointment in the tire wear that would be experienced with the newer conventional cars because of the general increases in power that are being introduced. He mentioned the acuteness of the problems of camber and toe-in that had come with the use of balloon tires. Mr. Snow held out the hope that front driving, because of the steady steering conditions secured with almost no camber and toe-in, would improve front-tire conditions.

A question about worm-drive lubrication brought from Chairman Litle the suggestion that powdered lead-carbonate, carefully ground in mineral oil, might help in this respect. Such a mixture is used on lathe centers and in small portable worm-driven hoists. It is also used in the steering-gear of a prominent high-priced automobile.

New Problems in Body Design

Joseph Ledwinka, of the Edward G. Budd Mfg. Co., presented a short paper on Bodies for Front-Wheel-Drive Cars, in which he said that determining the over-all height of the body of a rear-drive sedan is a simple matter of arithmetic. High hats not being in fashion, body heights can be made as little as about 69 or 70 in. One front-drive sedan at the Paris show was only 54 in. high. He asserted that only a contortionist could safely enter such a mole-hill on wheels from the level of the street, and even the contortionist would have been obliged to give up if the car had been drawn up to the curb. He believes that 65 in. is as low as any car should be for comfortable ingress, and recommends taking advantage of the possibilities of the front drive to lower the floor and provide better rear-seat springs—especially at the center, where cushion springs sometimes are abbreviated—to make the car more comfortable.

Better use can be made of the lower height in open and sport bodies, in the

THOSE WHO TOOK CHIEF PARTS IN THE FRONT-DRIVE SESSION

(Top) T. J. Litle, of the Holley Carburetor Co., Occupied the Chair; (Left) William Muller, of the New Era Motors, Read a Paper on Front-Wheel Drive; (Right) Joseph Ledwinka, of the Edward G. Budd Mfg. Co., Spoke of Body Design for This Type of Chassis; and (Bottom) Herbert Chase, Associate Editor of *American Machinist*, Discussed Front-Drive Design

opinion of George J. Mercer. Closed bodies have been made so low that doors cannot open over an 8 in. curb, and people entering have bumped their backs on the tops. George L. McCain, of the Chrysler Corp., supported Mr. Ledwinka's suggestion of giving the passenger greater comfort without materially lowering the over-all height of the car.

The elimination of the running-board was considered. The running-board is unnecessary in facilitating entrance, but Mr. Ledwinka said that it is impossible to keep paint on the rear fenders without running-boards, on account of gravel thrown by the front wheels. Much more mud is spattered over the whole body, too, without a running-board. Elimination of the chassis frame was mentioned by Lyle K. Snell, of the Eaton Axle & Spring Co., as much more of a possibility with the front-drive than with the rear-drive car.

A question from Chairman Litle brought from Mr. Ledwinka a confirmation of Colonel Wall's statement that gear noises are more noticeable in a front-drive car. The cowl seems to amplify the sound like a radio horn. However, less difficulty has been found from propeller whip. Mr. Snell called attention to the fact that air currents from the front help to carry front noises to the passenger.

During the session, nominations were made for a Nominating Committee for Vice-President of the Passenger-Car Activity. Results of the balloting were announced at the close of the meeting by Mr. McCain, as follows: Chairman, Walter C. Keys; Members, W. J. Davidson, T. J. Litle, Jr., H. T. Woolson; Alternates, F. F. Kishline and W. T. Fishleigh.

Treatment Accorded Inventors

Systematic Consideration Given to New Devices by Big Corporations—Inventors Criticize Patent Procedure

INVENTORS and the companies they seek to interest in their ideas had a session of their own for the first time at the 1930 Annual Meeting and took advantage of the opportunity to present their respective views of a difficult and sometimes annoying situation. Under the chairmanship of J. A. C. Warner, of the Studebaker Corp, of America, W. J. Davidson, of the New Devices Committee of the General Motors Corp., delivered a most interesting paper explaining why this committee was set up, the treatment it accords inventors who submit their ideas to the corporation, and its method of handling the thousands of ideas presented yearly.

George L. McCain, of the Chrysler Corp., gave prepared discussion on the subject, in which the corresponding methods of the Chrysler organization were explained, and Chairman Warner gave in open discussion some details of the Studebaker system of handling inventions and inventors.

Designers and inventors, of whom many were present, then had their innings and seized the opportunity to ask questions for further enlightenment, to voice some complaints regarding patent procedure and to offer several suggestions.

An Inventions Clearing-House

The New Devices Committee of the General Motors Corp. was organized to remedy an unsatisfactory situation which Mr. Davidson said existed because every year approximately 6000 inventions or ideas were submitted through the various channels of the organization and, because of the lack of a definite policy of dealing with them, the inventor sometimes did not receive proper consideration. The committee was therefore organized as a central clearing-house for all such inventions and, instead of allowing a possibly meritorious device to drift by a devious route through various channels, the committee steers it with the minimum delay directly to the person most vitally concerned.

The composition and systematic methods of the committee were described, and in the discussion later Mr. Davidson stated that two years ago a pamphlet covering this subject was printed and distributed among the corporation's stockholders, to banks and through miscellaneous other channels. This explains how to submit a device to the General Motors Corp. so as to have it receive prompt, careful and courteous consideration. The committee, it was made plain, does not deal with commercial articles the manufacturers of which seek to have adopted.

The corporation is interested in receiving ideas or suggestions relating in any way to the improvement or manufacture of its various products and, although last year only 11 out of about 6000 such ideas were regarded after careful examination as possessing sufficient merit to warrant further thorough consideration, the corporation does not want to overlook any device or idea that may prove of value.

There are certain classes of inventions in which the corporation has no interest, such as perpetual motion ideas and those that do not have application to present fields of activity of the various divisions of the organization. Ideas that are not patentable or for which no patent application has been filed cause the committee the most concern. To protect both the inventor and the corporation, anyone desiring to submit an idea on which a patent has not been secured or an application filed is advised to first obtain at least the minimum legal protection.

The submission of devices or ideas is promptly acknowledged and the ideas are given early consideration. Then in most cases the inventor receives a letter stating courteously that the corporation is not interested in the idea but giving no reason. Inventors never are permitted to be present at meetings of the committee. Should the corporation be interested in an invention, it enters into a written agreement with the inventor setting forth the terms on which it will undertake investigation of the device and the compensation it will give if it makes use of the invention.

Much of Mr. Davidson's paper was devoted to discussion of inventors and inventions and the reasons for the pitifully small percentage of ideas that are sufficiently meritorious to be worth serious investigation and test.

Policy of the Chrysler Corp.

Mr. McCain, in his prepared discussion, classified inventors into four general types and quoted from a letter reflecting the feeling of disappointment and cynicism of a cowboy who evidently had received a we-are-not-interested letter. The policy of the Chrysler Corp. is to encourage the inventor with a new idea, maintain his good-will and take considerable time in investigating a new device or theory that is submitted. This sometimes results in the company learning something of value that it would not have learned if it had rejected the idea on the basis of its general characteristics without a thorough analysis; moreover, a discussion with the inventor will often satisfy him of the impracticability of an idea.

In most cases it is a waste of time to send an engineer to witness a demonstration of a model in another city. Such a procedure may be ideal for the promotor who is trying to sell stock in some scheme, but if the device has real merit a description, with photographs or drawings, will suffice for the engineer to form a correct idea of its function and arrive at a fair decision. The real value of a demonstration lies in the illustrating of a theory that has been explained with a careful analysis of the fundamentals involved.

The practical mechanic is one of the hardest persons to deal with, because of his mechanical ability, his ignorance

of the laws of physics and the fundamental science of mechanics and his lack of access to records of the prior art. In this class, according to Mr. McCain, are the convict who invents a lock to prevent automobile thefts and men who make models of various devices to accomplish perpetual motion.

Public demand, competition and style dictate engineering policy, and automobile merchandisers should and do know what the public will accept. Many inventions have practical utility but cannot be adopted because a sufficient percentage of car purchasers will not accept them. For example, revolutionary inventions have been incorporated into automobiles in advance of public acceptance and have failed, only to reappear when the public or the related conditions were ready for them. Automobile engineers know of many principles that could be applied in devices for automobiles which would please a few owners and positively help sell cars to them but which would be useless or unnecessary to a large majority of car users.

Inventors often ask, "What can I work on and submit that you *do* want?" said Mr. McCain. Among the many things that are desirable the corporation has suggested the showing of a way to increase the thermal efficiency of the present internal-combustion engine; a cooling fluid that is cheap, has a high boiling-point and that will not corrode metal; and a way to save some of the waste energy that goes out through the exhaust.

Studebaker Attitude Toward Inventor

Chairman Warner, in commenting on Mr. Davidson's address, remarked somewhat facetiously that the General Motors Corp. probably acts as a sort of sieve in the matter of inventions and is getting the cream, so to speak, as Studebaker probably finds only about 1 in 6000 that is worth according much attention. The attitude of the Studebaker Corp. toward inventors is the same as that of General Motors, but it has three form letters which it uses in communicating with inventors: one acknowledging receipt, the second asking for additional information and the third stating that the invention is receiving the attention of the General Committee on Patents.

As a prelude to the papers and discussion at the session, Mr. Warner showed a series of lantern slides of pioneer motor-vehicle inventions dating back to the late 18th and early 19th centuries in France and England and commented humorously upon them.

CHIEF PARTICIPANTS IN THE INVENTIONS SESSION

W. J. Davidson, of the General Motors Corp., Described the Methods of the New Devices Committee of the Corporation; John A. C. Warner, of the Studebaker Corp., Presided and Took Part in the Discussion; and George L. McCain, of Chrysler Motors, Described How That Corporation Handles New Ideas Submitted To It

Mr. McCain commented on certain pathetic phases of the invention situation and said that the set-up of the Chrysler Corp. inventions committee is rather similar to the General Motors Corp. New Devices Committee. When a new device that has no protection is submitted, the inventor is asked to have the letter in which he describes it notarized so that the date can be established legally, if necessary. Such ideas, however, are rarely of interest, as a man who is qualified to produce something good has had enough practical experience to have his invention protected.

The Ford Method

Although the Ford Motor Co. does not have so definite a committee organization as General Motors, said W. T. Fishleigh, it functions in much the same way, suggestions that come ultimately through the management or engineering department being passed to certain individuals as a subcommittee which has authority to act immediately on inventions in certain impractical classes and turns over to a rather large committee those which have some merit. Although the method varies in details with different companies, Mr. Fishleigh said he was impressed with the desire of all to be fair, first, with the inventor and, second, with the company. Nevertheless, in many cases the inventor feels that he is not being treated fairly.

The Ford company probably has more than 6000 suggestions offered to it in a year. One of the great pressures the inventors bring upon it to make a quick, and presumably favorable, decision is a statement that "General Motors is hot after this thing," and Mr. Fishleigh imagined that they tell the General Motors and the Studebaker people that Ford is keen to get hold of their inventions.

Speaking with reference to the Packard Motor Car Co., Milton Tibbetts remarked that there is certainly a unanimity of opinion among the companies as to how the inventions problem should be handled and that the way in which the large corporations deal with inventors is the only way of doing it. It is necessary to be firm in rejecting ideas and useless to enter into discussion with the inventors. S. M. Udale, of the Holley Carburetor Co., suggested that one way of getting out of an awkward situation is to direct the inventor to have a patent search made; however, he criticized the method of classification of patents in Washington and suggested that they be classified under more than just the claims. Foreign patents, especially in Germany, are much better classified, and if a person has not time to make a complete search he can frequently get data on foreign patents quicker than on American patents.

Board of Patents and Design

However sympathetically one starts out to examine patents, said Edward P. Warner, ex-Assistant Secretary of the Navy for Aeronautics, he almost inevitably acquires an extremely cynical attitude on the subject after a few months. Because much time was wasted in the Army, Navy, Department of Commerce, National Advisory Committee for Aeronautics and other Government departments and bureaus in talking with inventors who went from one to the other, the Morrow Board recommended the coordination of this work under the National Advisory Committee, and the Congress in 1926 included a section in the statutes that provides for the creation of a Board on Patents and Designs.

This Board consists of the Secretaries for Aeronautics of the Army, the Navy and the Department of Commerce, who receive and report to the National Advisory Committee on all

(*Continued on p.* 275)

Through Highways the Annual-Dinner Topic

S. D. Waldon Tells Notable Gathering of 850 Members and Guests How Traffic Congestion Should Be Relieved

SOCIABILITY, a beefsteak dinner and highway relief were mixed and compressed into three hours of enjoyment at the Annual Dinner in the grand ballroom of the Hotel Pennsylvania in New York City in the early evening of Jan. 9. Eight hundred and fifty members of the Society and their guests began assembling at 5:30 p.m. and spent the next half-hour in handshaking, helloes, introductions to new acquaintances and the other usual preliminaries to a dinner meeting of the Society.

Above all others, the Annual Dinner, held as it is in the week of the New York Automobile Show, brings together old friends and acquaintances both in and outside of the Society who sometimes have not had the pleasure of meeting for a year or more. So the sociability runs unusually high and continues through and after the dining, which, however good the food and service, is of secondary interest to intertable visiting. Table numbers ran to 116, nine tables being set in the balcony, from which the diners could see and hear to even better advantage than from parts of the main floor, the Society's public-address system contributing vastly to the audition.

Orchestral and vocal musical numbers were rendered by Vincent Lopez and his orchestra during the dinner and received the plaudits of the assemblage.

Prominent Among Those Present

Seated at the speaker's table on a dais at one side of the ballroom were the following officers and guests of honor:

W. R. Strickland, President of the Society
Edward P. Warner, President-Elect
William B. Stout, Toastmaster
Sidney D. Waldon, Speaker
Sir Herbert Austin, of England
John Jay Ide, Advisory Committee for Aeronautics (England)
Brig.-Gen. W. E. Gillmore, Assistant Chief, Air Corps, War Department
Col. E. D. Bricker, Office of the Chief of Ordnance, War Department
Thomas H. MacDonald, Chief of Bureau of Public Roads
A. J. Brosseau, Vice-President, National Automobile Chamber of Commerce
Henry R. Sutphen, President, National Association of Engine and Boat Manufacturers
J. M. McComb, President, Motor and Equipment Association
Capt. E. S. Land, Vice-President, Daniel Guggenheim Fund for the Promotion of Aeronautics
A. A. Woodruff, of the Aeronautical Chamber of Commerce of America
Sidney R. Dresser, Chairman of the Annual Dinner Committee.

Past-Presidents of the Society who were present at other tables were William G. Wall, J. H. Hunt, H. L. Horning, H. M. Crane, B. B. Bachman and David Beecroft. Past-Treasurer Whittelsey, who has been succeeded by C. B. Whittelsey, Jr., was also in attendance, as well as many present and past Vice-Presidents and Councilors.

Election of Officers Announced

Following the serving of ice-cream pie and coffee, President Strickland pounded the table with the gavel, to the imminent risk of the glasses, and announced the opening of the Annual Business Meeting of the Society. This proved to be probably the briefest such meeting in the history of the organization. Results of the election of officers for 1930, as counted by the tellers, were referred to as being printed on yellow slips in the Dinner program and menu. The record of the ballots and portraits of the new officers and all members of the Council to serve during this year were published in the January number of THE JOURNAL, pp. 5 to 9. Reading of the names was, therefore, dispensed with, but President Strickland called upon President-Elect Edward P. Warner to stand up. Whereupon Mr. Warner received the hearty applause of the audience.

SIDNEY D. WALDON
Speaker at the Annual Dinner and President of the Detroit Rapid Transit Commission

Upon motion made and seconded, the meeting was then adjourned to Monday, Jan. 20, at the Annual Meeting in Detroit, where annual reports of Administrative and other Committees were to be presented and the new President inducted into office.

Toastmaster Stout was then introduced, which was a superflous courtesy, for, as President Strickland said, "You all know him."

The Three-Dimensional Viewpoint

Viewing in prospect, from the aeronautic man's angle of vision, Mr. Waldon's address, Increasing the Capacity of American Highways, Mr. Stout remarked that "Those who still grope around on the ground on four wheels perhaps never have experienced anything like three dimensions, but your new President, General Gillmore, Chance Vought and Captain Land and some of the rest of us here believe the old song, All God's Chillun Got Wings." The aviation industry is developing along more or less parallel lines with the automobile industry, he continued. It has taken most of its beginnings, as wheels, tires, materials and manufacturing methods, from the automobile business and is now beginning to hand back some airplane developments that are making changes in automobile design and construction.

Reference was made to some discussion at the speaker's table during the dinner to the import that anyone who knows only one line of business and pays no attention to others is likely to miss some of the things pertaining to his own business. Unless we look to some outside developments that are related to the automobile, we are likely to run into problems which the motor-car organizations will have difficulty in solving.

The automobile business has been so prosperous that it is now choking itself on the roads on its own prosperity, said Mr. Stout. The question of more roads and space for cars has become a basic problem. Colonel Waldon, he said, has made a study of the prob-

lem for many years and developed some ideas regarding highways, not only for today but for the future.

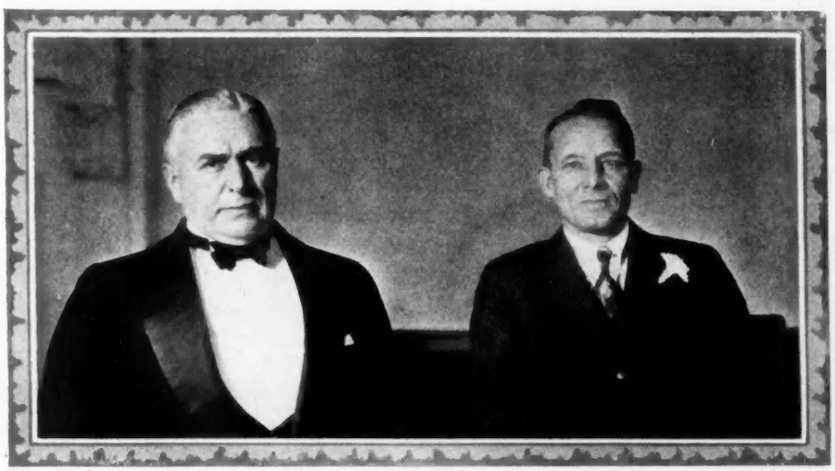
Highway Subject's Several Phases

Colonel Waldon divided his subject into seven phases: the future growth in motor-vehicle ownership and use, increasing urban congestion of population, the problem of increasing facilities for distance travel in great urban centers, the need for a continuing program of improvement to keep pace with increasing traffic needs, the need for a master plan superior to municipal and county boundaries, coordination and cooperation of municipal, county and State authorities, and new facilities for the use of automobiles with speed and safety.

Pointing out that traffic congestion is greatest in and near great cities and the rapid growth of cities, the speaker showed by statistics that New York City has 286 car registrations per mile of paved streets for both local and through traffic. This is sevenfold the average per-mile registrations in the States of New York, New Jersey, Pennsylvania, Massachusetts and Virginia outside of the large centers of population. More motor-vehicles are concentrated in the streets of Detroit than there are in any of 29 States of the Union, and the Detroit registrations exceed the combined registrations of five great Western States by 94,000. These facts were cited to give a clearer picture of the great need for improving through-traffic facilities in growing cities.

WILLIAM B. STOUT AND WILLIAM R. STRICKLAND

Respectively Toastmaster and Presiding Officer at the Annual Dinner



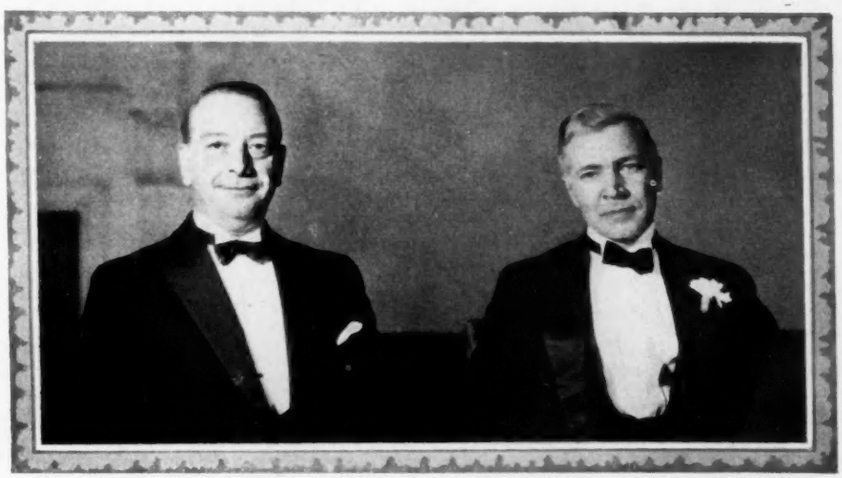
HENRY R. SUTPHEN AND CAPT. E. S. LAND

Respectively President of the National Association of Engine & Boat Manufacturers, and Vice-President of the Daniel Guggenheim Fund for the Promotion of Aeronautics

Cities Now Need Road Aid

"It took nearly two years to convince the farmer, the strongest opponent of road improvement at that time, that he would benefit most from their construction," said Mr. Waldon. "When finally convinced, he joined hands with the city man in obtaining State and Federal aid in building the greatest system of improved roads in existence. The States and the Federal Government have built, with taxes supplied in great measure by the cities, this system of highways up to the gates of our great centers, and there they stop. The nearer we approach the center of a city, the greater becomes the congestion."

Estimating the growth in motor-vehicle registrations by 1965 in eight cities, the speaker said that every metropolitan area, county and State should have a master plan; that is, a regional plan transcending city boundaries and that will constantly keep step with increasing traffic needs. He then described the Detroit master plan offi-



A. A. WOODRUFF, OF THE AERONAUTICAL CHAMBER OF COMMERCE OF AMERICA, AND SIDNEY R. DRESSER, CHAIRMAN OF THE ANNUAL-DINNER COMMITTEE

cially adopted by the three counties of Wayne, Oakland and Macomb and the various municipalities making up the Detroit district. Super-highway commissions have been created for the acquirement of 120-ft. rights-of-way, and in the last five years more than 600 miles of frontage right-of-way has been acquired. In the outer area, a standard width of 200 ft. is used on 251 route-miles. There are 20 such highways.

This master plan will save the taxpayers of Detroit hundreds of millions of dollars in condemnation costs through generations to come, according to Mr. Waldon, but more important is the fact that these increased trafficways are being made ready automatically as they are needed.

Vehicle Tax Can Pay Cost

The cost of providing suitable traffic facilities in New York City would not be prohibitive, as vehicle tax-revenue keeps pace with registrations. At an average of $35 per vehicle, 5,000,000 vehicles would pay $175,000,000, which would pay for three Holland Tunnels and five Bear Mountain Bridges every year, or, exclusive of right-of-way and property damage, would build a four-lane elevated motor roadway four times around the Island of Manhattan every year.

State governments have large powers and large funds that may be expended upon trunk highways in a way to make continuous improvement keep pace with increasing needs. The problem is to get the available funds applied wisely in the right places in accordance with a master plan. There is every reason why State governments should now use an increasing proportion of revenue, derived mainly from taxation of city-owned and city-operated vehicles, in improving trunk-line traffic facilities in the cities and metropolitan areas. Just as the intelligent use of Federal Aid funds upon a National system of highways automatically brings about cooperation between States, so would the use of State funds invite active cooperation of municipalities in carrying out a program designed for the greatest benefit of the metropolitan areas as well as the rest of the State.

OTHER HONOR GUESTS AT THE SPEAKERS' TABLE AT THE ANNUAL DINNER

Upper Row, Left to Right—Brigadier-Gen. W. E. Gillmore, Assistant Chief of the Air Corps, War Department; Sir Herbert Austin, K. B. E., Chairman of the Austin Motor Co., Ltd., of England; and John Jay Ide, of the Advisory Committee for Aeronautics (British)

Lower Row, Left to Right—Thomas H. MacDonald, Chief of the United States Bureau of Public Roads; A. J. Brosseau, Vice-President of the National Automobile Chamber of Commerce; J. M. McComb, President of Motor & Equipment Association; and Col. E. D. Bricker, Office of Chief of Ordnance, War Department

Society Cooperates in Motorboat Meeting

Joins Manufacturers' Association in Technical Sessions and Dinner—Diesel Engines and Electrical Installation Discussed First Day

BECAUSE of its location in the Grand Central Palace, where the Motorboat Show was being held, and of the facilities provided, the Westinghouse Lighting Institute proved an ideal meeting-place for the technical sessions of the joint Motorboat Meeting of the National Association of Engine and Boat Manufacturers and the S.A.E. The assembly hall, which is part of an extensive exhibit of lighting arrangements and settings, is provided with a stage of convenient size, a screen that lowers like a curtain and a reading lamp for the speaker arranged at one side so that it does not interfere with the screen.

Austin M. Wolf was Chairman of the first session, which met Wednesday afternoon, Jan. 22. He hailed the event as an occasion for amalgamating the activities of the Association and the Society, particularly in regard to the establishment and use of standards for motorboats.

The first paper was given by O. D. Treiber, of the Treiber Diesel Engine Corp., on the subject of Diesel Engines for Motorboats. He said that the heavy slow-speed type of Diesel engine had been used almost exclusively during the last decade for the powerplants of pleasure boats 100 ft. and more in length. These engines have given good service but are too heavy for motorboats and fast yachts. The speed of boats equipped with such engines is limited to 12 to 14 knots.

Light Engines for Fast Boats

Development of light Diesel engines for fast boats was begun in 1926, with a V-type 12-cylinder 16 x 16-in. reversible engine, designed to deliver 5000 hp. Before this, ordinary Diesel engines of the same power weighed about 1,000,000 lb., said Mr. Treiber, and a 10-cylinder, 21 x 21-in. submarine engine weighed about 180,000 lb. Two of these Treiber engines, weighing 63,200 lb. each, propel a 160-ft. boat at 40 m.p.h., with a fuel consumption of 0.37 lb. per hp-hr.

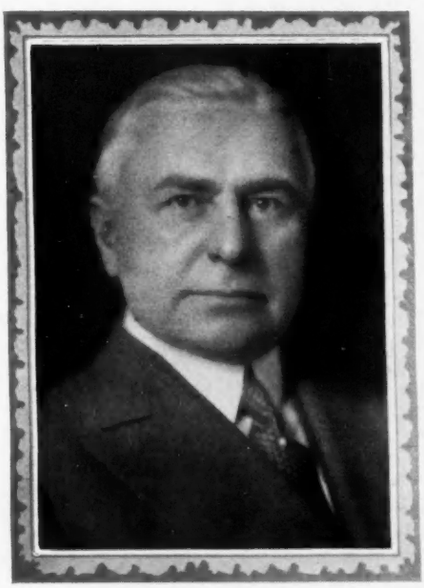
Each of these engines is controlled completely by a single hand-wheel at the forward end, the wheels of both the port and starboard engine being within easy reach of the engineer. Emergency stop levers will stop the flow of oil instantly, to prevent the engine from running away and doing damage in case of accident. The cylinders are forged from chromium-vanadium steel, heat-treated, and no cast iron is used in their construction. The pistons are cooled by oil pumped by means of grasshopper connections through coils cast in the piston-heads.

A brief discussion and illustrations of this and several smaller engines were given by Mr. Treiber, the smallest of them having 5 x 7-in. cylinders ranging in number from one to six. One of the smaller engines is fitted with an inertia starter. Several boats powered with the Treiber engines were shown also.

Mr. Treiber, answering questions in the discussion, gave an account of the difficulties encountered in finishing the cylinder liners of his largest engines. He was not prepared to give definite figures on the cost of Diesel engines, and said that no direct comparison could be made with the cost of gasoline engines because of the great disparity in production quantities. With equal production, he believes that the cost of the Diesel engine will be about 15 per cent more than that of the gasoline engine if it weighs 15 per cent more, but the injection nozzle of a Diesel engine can never be made so inexpensively as a spark-plug.

Standardization Applied to Cruisers

Defense of the standardized motorboat was the theme of the second paper, given by H. R. Sutphen, vice-president of the Submarine Boat Corp. and president of the National Association of Engine and Boat Manufacturers. He has championed the production of standardized models for a number of years, and expressed pleasure in the variety of standardized cruisers on exhibit in the current motorboat show, ranging in length from 27 to 55 ft., and in price from $3,500 to $45,000.



HENRY R. SUTPHEN

President of the National Association of Boat & Engine Manufacturers, Who Presented a Paper on Boat Standardization

Standardization has made it possible for the boatbuilder to improve in both design and production, said Mr. Sutphen, who finds that the buyer has learned to recognize the value that can be secured on this basis. Formerly it was thought that stock boats were made of inferior materials and by unskilled workmen, with the sole idea of cheapness, and some early boats of the sort may have justified the opinion; but visitors to the yards of the better builders see that many details are better provided for in the standardized boat than they are likely to be in one built to order. So-called "back-yard" competition from local men who build only a few boats is being overcome, because such men find it more profitable to sell standardized cruisers.

Among the advantages of standardized construction as given by Mr. Sutphen are economies in design and production; the ability to secure appropriate materials, fittings and accessories; refinements in design; economies in servicing; and higher resale value. The best value can be secured when boats of a certain size are built for a definite amount of power and with a single cabin arrangement; a design made to allow for a range of power is not so efficient.

Gerald T. White, of *Motor Boat*, started the discussion by asking how much hope there is for the $5,000-a-year man to own a cruiser. Mr. Sutphen told of a lunch-wagon proprietor on Staten Island who owns a cruiser. Irwin Chase, of the Elco Works, said that it would be just as sensible to say that such a man cannot afford to live in a house, and a considerable number of cruisers go to men in that income class. Building standardized boats tends to reduce depreciation, insurance and other costs, as well as the first cost.

Lighting for Motorboats

R. E. Carlson, of the Westinghouse Lamp Co., introduced the subject of lighting by giving graphs explaining characteristics of electric lamps and

emphasizing their sensitiveness to change in voltage. He argued strongly for the voltage-regulated generator, because it prevents the voltage rise that is characteristic of the third-brush generator at a certain stage of battery charge.

This introductory part of his paper, which follows much the same lines as are found in Mr. Carlson's paper printed in the S.A.E. JOURNAL for Nov., 1929, p. 515, was followed by a list

R. E. CARLSON

Commercial Engineer with the Westinghouse Lamp Co., Who Gave a Paper on Boat Lighting and the Need for Standardization

of the great variety of lamps used in motorboat lighting and a plea for the general adoption of standardized lamps. The list recommended by the Motorboat Division of the S.A.E. Standards Committee was presented as covering the needs for sizes up to those used in domestic lighting.

Discussion of Mr. Carlson's paper was deferred until after the reading of the paper on Electric Lighting and Auxiliary Power on Pleasure Craft. This paper was written by C. G. Meeker, of the Smith-Meeker Engineering Co., and in his absence was read by Gerald White.

The electrical installation on a yacht is said to be second in importance only to the main powerplant, but no rules apply specifically to this work. In early installations, ordinary house wire was covered with wood moldings, and even bell wire was often used for 6 and 12-volt systems in launches. Iron pipe was used in the larger steel boats.

Water-Tight Fittings Needed

The so-called Navy cable was developed and has since been specified by many naval architects, but Mr. Meeker warns that this material has no virtue unless space is allowed for the special fittings developed by the Navy to secure water-tight joints. Unless metallic conduit is installed with suitable outlet boxes, non-metallic conduit is thought better for use back of joiner work, because nails seldom do much damage to that unless they actually cut the wire. Neither the commercial lead-covered wire nor "B.X." should be used in a concealed location.

Warnings and suggestions were given by the author on many other points, such as location of wiring, arrangement of circuits, and switches. The paper closed with a recommendation that boat architects, builders and owners join with electrical manufacturers to form a few simple and practical rules for electrical installations on boats of the various classes. Chairman Wolf heartily supported this suggestion, saying that the movement should be initiated without delay.

Discussion of the two papers on electrical subjects followed, the high spot of which was furnished by H. H. Brown, who formerly was a familiar figure at meetings of the Metropolitan Section. He said that the electrical installation often is a very minor consideration in buying a boat but is very important when the owner comes to live aboard the boat. Mr. Brown has met the resulting problem by installing a second battery in a boat of his own. He also called attention to the influence of the Board of Underwriters in granting or withholding approval of insurance on a boat.

After the session, many of the guests were conducted through the exhibits of the Westinghouse Lighting Institute.

Safety and Outboard Engines

Newell and Dunnell Papers Bring Out Fire-Prevention and Standardization Suggestions

THE SECOND afternoon session of the Motorboat Meeting was held on Jan. 23, with A. E. Luders in the chair. A paper on Safety on Boats, written by H. E. Newell, of the National Board of Fire Underwriters, was read in the absence of the author by E. W. Fowler, and was followed by a paper dealing with Outboard Motors, by Jacob Dunnell, of Ludington Aircraft, Inc.

Mr. Newell's paper was a clear and systematic exposition of the various types of fire hazard attending the operation of motorboats of present design and construction, together with pertinent suggestions, approved by the underwriters, for the elimination of these risks. The general impression produced by this paper is that, together with the chance of short circuits and other electrical trouble, motorboat fire hazard is in the main conditioned by the accumulation of combustible gasoline vapor in the bilges of the boat. Hence, ventilation is indicated as the most promising way out of a difficult, if not to say critical, situation, and the discussion centered on this idea.

Inflammable Gas Indicator Needed

Several important points were brought out by L. Ochtman, Jr., of the Elco Works, who emphasized the need of ventilating the boat both before and after starting of the engine, though he added that, with the ordinary type of boat construction, even 10-min. ventilation does not assure the operator of the absence of combustible vapors. He stated that the engine itself, drawing in air and using it, can serve as a very effective ventilator, provided the intake is low in the hull. Continuing, he said:

> It would seem that, to provide the greatest measure of safety, some device for indicating the presence of dangerous gases in the bilges should be worked out. I cannot say what form such a device should take, but it should be readily mountable by the operator, or of such a nature that he could take it into the engine room. The device should show him whether the gases, particularly down in the bilges, contain sufficient gasoline vapor to be dangerous. A device of this type would be a great help in fighting the motorboat fire menace.

James Craig, of the National Association of Boat & Engine Manufacturers, stated that, when considering the addition of mechanism to a boat, it is important to guard against rendering it topheavy. He also called attention to the advantages of the practice, formerly very popular with boat-engine builders, of designing flywheel spokes so as to make them act as blades of an exhaust fan.

Menace from Spilled Gasoline

Much of the fire menace arises from the haphazard dumping of the gasoline into boat tanks by employes of the filling stations, said Mr. Craig. He called for the development of a spill-tight standard connection between the tank mouth and the filler-hose nozzle, so that fuel can be put into the boat without spilling it.

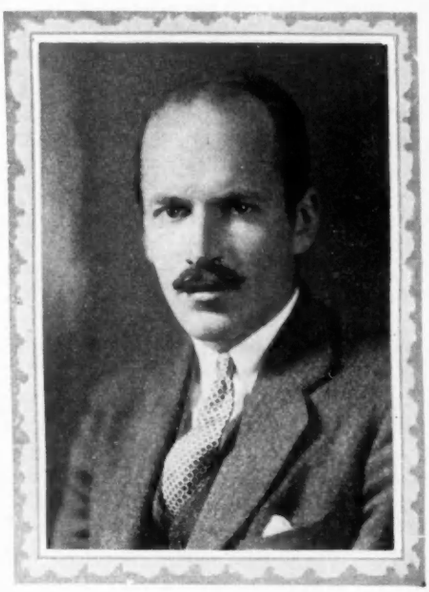
Agreeing with Mr. Craig's statement that the filling period is the time most fraught with danger, E. Greenfield, of

the American Safety Equipment Co., emphasized that even such a connection would not do away with the need of venting the tank and the risk of fire due to escaping gas. He described a device for protecting the filler neck of the motorboat fuel tank; this has double wire screens and affords safety on a principle related to that of the miner's lamp.

O. A. Ross, of the Ross Engineering Co., pointed out that there are at least three makes of boat in which the fuel tank is placed above the water-line in a separate compartment which drains to the sea, so that any fuel spilled in filling the tank flows overboard immediately.

Outboard-Engine Development

In his paper on Outboard Motors, Mr. Dunnell stated that the early development of this type of powerplant was slow, chiefly because the weight per horsepower, at the beginning of this century, was rather great. The first real step forward came after the war, in the form of a small, light, two-cylinder opposed engine of relatively high speed. It was of three-port design, had a float-type carbureter, a flywheel-type magneto and reduction of vibration through the opposed position of the cylinders. A 2-hp. model weighed 40 lb. and was later improved so that



JACOB DUNNELL

Reviewed the Development and Present Status of Outboard Engines

it now gives 3 hp., with a total weight of 38 lb. However, the outboard-engine power-weight ratio is very low today when larger power units are considered. A 30-hp. outboard engine weighs slightly more than 100 lb.; but this figure includes drive unit, fuel tank, muffler and other accessories, without which the weight of the engine proper is only a little more than 2 lb. per hp.

The real backbone of the industry is formed by small service-engines, weighing from 27 lb. up and giving a speed of 5 to 10 m.p.h. to any rowboat or canoe; with reasonable care, these engines give very little trouble and will run for an almost indefinite period at full throttle. These designs are mostly of the conventional two-cylinder, opposed, three-port type, with float carbureter and flywheel-type magneto. So far, all outboard engines are built as water-cooled types.

Mr. Dunnell then outlined the characteristic structural features of normal outboard-engine types and closed by regretting the lack of standardization in this field, saying:

It does not seem to me that it would in any way interfere with the efficiency or performance of any of the engines if a few of the more important parts which fit on to the boat were standardized. For instance, at present, several different lengths of drive-shaft are used on different engines. This means that a different-height stern must be built on the boat for each different engine. If the manufacturers could agree on the height, the task of the boat builder would be greatly simplified, as would also the position of the owner and driver. The same holds true for the angle at which the stern is set.

With regard to the standardization of outboard engines, Mr. Ochtman stated that the subject had recently been taken up by the Motorboat Division of the Society's Standards Committee. A committee is being formed by representatives of all outboard-engine builders, and some progress may reasonably be expected to be made this year.

Motorboat-Dinner a Wow

Bilge Monkeys, Galley Urchins, Water Commuters and Other Equally Important Personages Make Whoopee

THROUGH preaching Standardization the Society of Automotive Engineers has made business in general realize how valuable Standards are, said Toastmaster Henry R. Sutphen in the course of his introductory remarks at the Motorboat-Meeting Dinner, sponsored by the Metropolitan Section for the benefit of the members and guests of the Engine and Boat Mfgrs., Inc., and of the Society, and given at the Roosevelt Hotel, New York City, on Thursday evening, Jan. 23. That was some of the whoopee, as he is president of the National Association of Engine and Boat Manufacturers.

Ira Hand, secretary of the Association, was there too, or shall we say on deck also, or maybe on hand as usual. We cannot decide and therefore must pass it on, or pass the buck, or the goat or whatever. But genial Ira, who has devoted more than two decades of his life toward furthering the success of the Association, was present with bells on. So was "Tex," of the *New York Telegram*, often termed a newspaper. Less intimately, Tex is known in real life as Henry Clay Foster. Anyone who can listen to Tex's wisecracks and refuse to laugh is a personification of Crime. The side aches of the laughter lovers present could have been relieved by good liniment, but nobody had thought to bring any liniment.

Music Enlivens the Feast

The diners at the elegantly appointed tables were soothed by instrumental music at times, and aroused at others when all present sang the old-time songs to instrumental accompaniment. The Colonial Male Quartette, often heard over the radio, sang sailors' chanties and ballads and humorous ditties in person. Its members were in excellent voice, and they evoked great applause. Ira Hand calls them the Colonial Commodores.

Two Industries Involved

Toastmaster Sutphen explained that the lines of the engine and boat builders and of the automotive industry cross because both industries are engaged in constructing vehicles for service in transportation. Both are competing against the World, in their respective lines, and neither likes to be told how to run its own business. Concerning motorboats, he wondered just how well the general public realizes the difference between a necessity and a luxury. He emphasized that the motorboat is not a plaything, and maintained that people can use motorboats and live almost wherever they please and as they please at less cost than if living at home.

Ira Hand said that, in the United States, there is one motorboat to every 16 automobiles. Commenting upon this Silver Anniversary of the Motorboat Show, he characterized it as representing the greatest effort of any group, as a show, and said that it was the largest, the heaviest in point of exhibits, and the most costly, as compared with those held previously. He is studying how to make the next show the best in the world and, meanwhile, to make the general public "water-minded."

Chronicle and Comment

Summer Meeting at French Lick

AT its meeting held in New York at the time of the Automobile Show the Council considered the results of the canvass of the members as to their preference as between the three places listed for vote for the Summer Meeting this year. The decision was that the meeting should be held at French Lick, beginning on Sunday, May 25, and ending on Thursday, May 29. It was considered necessary to start the meeting on Sunday to provide time for a sufficient number of sessions and at the same time permit members desiring to do so to attend the 18th Annual International Automobile Race at Indianapolis on Friday, May 30. By direction of the Council, 100 box seats were reserved for members of the Society, those desiring to purchase tickets being asked by mail to send their request to the office of the Society in New York City before April 1.

Gift to Past-Treasurer Whittelsey

AT a closing session of the 1929 Council, hearty recognition was expressed of Charles B. Whittelsey's 12 years of service as Treasurer of the Society. It was greatly regretted that Mr. Whittelsey felt that he should not continue in this office, which he administered for more than a decade not only most faithfully but with the highest credit as to the increasingly satisfactory financial condition of the Society. No one has been of greater service in this connection or in the Society's affairs generally.

As a token of great appreciation and of admiration and affection, a traveling clock mounted in a gold case was presented to Mr. Whittelsey, with remembrance inscription including the facsimile signatures of the 12 Presidents of the Society during whose administrations Mr. Whittelsey was Treasurer from 1918 to 1930.

C. B. Whittelsey, Jr., who was elected to serve as Treasurer this year, took office at the close of the Annual Meeting held in Detroit last month. As has been announced in THE JOURNAL, Past-Treasurer Whittelsey recently was elected Executive Vice-President of the Chamber of Commerce of Hartford, Conn.

The Roster for 1930

EARLY this month the Membership Roster of the Society for the year 1930 will be printed and distributed. Members who have not already sent requests to the headquarters of the Society for copies should do so promptly so that they will have the correct company connection and address of members of the Society.

Owing to the increase in membership, the Roster for this year will be printed on pages of somewhat increased length to avoid making too thick a book. Otherwise the arrangement of the contents will be the same as last year.

Additions to the contents include a list of members who have died since the 1929 Roster was issued, and a list of those whose addresses are unknown.

Effect of Calcium Chloride upon Metals

IN numerous instances corrosion of metals used in motor-cars has been attributed to the use of calcium chloride for removing ice and snow from streets. The criticisms refer especially to corrosion of chromium-plated parts. It is stated that some of the motor-vehicle makers use calcium-chloride solutions in corrosion tests, as this medium is the most corrosive substance with which vehicles are likely to come in contact.

The Bureau of Standards states that calcium chloride is more corrosive of most metals than is sodium chloride such as may be present in a marine atmosphere; calcium chloride, being deliquescent, maintains a film of solution in contact with metal, whereas a film of sodium-chloride solution may evaporate almost completely to dry salt when the humidity is low, as is usually the case in winter inside a garage or in a heated space. The calcium-chloride solution is drawn very readily into all cracks on the surface or between different metal parts, and is very difficult to remove by ordinary washing methods.

There appears to be no doubt that the use of calcium chloride on the streets will materially increase the corrosion of motor-cars.

Two Sections for This Number

THIS issue of THE JOURNAL consists of two sections, Section 1 being the regular monthly issue for February and Section 2 the Index to Vol. XXV, covering the issues from July to December of last year. Any reader who fails to receive a copy of the Semi-Annual Index as part of this issue of THE JOURNAL is requested to notify the Publication Department at the Society's headquarters in New York City and one will be mailed to him.

In the future, the index to each half-yearly volume of THE JOURNAL will, it is expected, be published as Section 2 of the issue following the completion of the volume. In other words, the index to the volume covering the first six months of a given year will be published in connection with the July issue, while that for the volume covering the last half of a year will be published as Section 2 of the January issue of the following year.

Cutting of Metals

W. H. McCOY has been named as a representative of the Society on the Special Research Committee on Cutting of Metals organized by the American Society of Mechanical Engineers in 1923. W. W. Nichols is Chairman of this Committee. During the last year, Secretary Boston, of the Committee, prepared for publication a bibliography on the cutting of metals. Progress has been made in collecting and correlating data relating to cutting fluids. A subcommittee is making a study of matters involved in the use of cemented tungsten-carbide for cutting-tools.

Downdraft Carburetion

By E. H. SHEPARD[1]

ANNUAL MEETING PAPER *Illustrated with* DRAWINGS AND CHARTS

GENERAL adoption of pressure fuel-feed systems on automobiles in the last three years turned many designers' thoughts to the desirability of placing the carbureter on top of the manifold. The idea was not new, as examples of such application date back more than 20 years. The recent development may have been hastened by use of inverted carbureters on a few racing cars; moreover, in many cases the only available space for the carbureter is above the engine. In the last year and a half a demand for downdraft carburetion has swept through the marine field and, according to the author, almost all leading marine-engine manufacturers will use downdraft carbureters this coming season.

Updraft and inverted carbureters in which the point at which the fuel joins the airstream is above the fuel level in the float-chamber require a high air-flow velocity to assure a flow of fuel from the jet orifices and to carry all the fuel into the engine.

In the radically different type of downdraft carbureter illustrated and described, the fuel outlet is below the fuel level so that the carbureter has a flow characteristic that follows the engine requirements at all speeds for wide-open-throttle operation. In addition, a taper needle in the jet is connected to the throttle to increase the area of the orifice as the throttle is opened, enriching the mixture progressively. This needle alters the characteristic curve of mixture ratio for low air-flow velocity and closed-throttle operation.

Comparative horsepower curves presented show an increase of 10 to 13⅓ per cent over the whole range of engine speed from 1600 to 2300 r.p.m. by the use of the downdraft carbureter as compared with the updraft type. This results largely from increasing the volumetric efficiency through the use of larger manifolds, increased air-flow through the carbureter and reduction in the hot-spot area.

HAVING the carbureter mounted on top of the intake manifold is no novelty, for there are many examples of such an application in automobile engineering, some of which date back more than 20 years. We have, however, for the most part, used updraft carbureters, or, as they are usually termed, vertical carbureters, in the majority of automobile designs. The basic reason for this, no doubt, has been the type of the fuel-supply system, as most car designs for nearly 20 years included a vacuum tank as a part of the fuel-feed system, and the carbureter float-bowl was filled by gravity from this tank. This made the location of the carbureter below the intake manifold a necessity if sufficient head was to be obtained on the float-bowl.

During the last three years a great change has been made in fuel-feed systems, and vacuum tanks are almost the exception rather than the rule. In their stead has come a pressure feed supplied by a mechanical pump operated from some engine shaft. With this development, the possibility of putting the carbureter on top of the manifold came to the minds of many designers. This may have been hastened by the use of inverted carbureters on a few racing cars which seemed to be faster than similar cars that had updraft carbureters. At any rate, considerable interest in the subject is being shown throughout the automotive industry, and I shall try to explain some of the results that may be expected from development of this type of carbureter.

There are cases in which a downdraft carbureter is almost a necessity, as the only available space for carbureter installation is above the engine. In some such instances it may not be imperative to secure maximum engine performance, and for this sort of application one may select from three or four makes of carbureter.

Demand for downdraft carburetion has swept through the marine field in the last year and a half, ever since the Holley Carburetor Co. equipped the Scripps 200-hp. engine with its radically different type of downdraft carbureter. This same type will be used by almost all of the leading marine-engine manufacturers this coming season.

Let us see wherein this carbureter differs from the conventional carbureters.

Fig. 1 shows an inverted carbureter of the conventional type such as has been available for 10 or 12 years. Observe that the point at which the fuel joins the airstream in the venturi is above the fuel level in the float-chamber, necessitating considerable velocity of air to assure a flow of fuel from the jet orifices. This velocity is rather higher than open-throttle conditions, a lineal velocity of approximately 2600 ft. per min. is required to cause a flow sufficient for full power.

In an updraft carbureter, when the air velocity past the jet falls to around 2000 ft. per min., fuel is drawn from the jet, but the velocity of air is not sufficient to carry all one might suspect; in fact, with

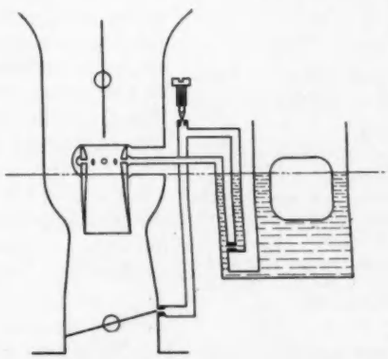


FIG. 1—DIAGRAMMATIC SKETCH OF A CONVENTIONAL INVERTED CARBURETER With Open-Throttle Conditions, a Lineal Air-Velocity of about 2600 Ft. per Min. through the Venturi Is Needed To Raise the Fuel above the Level in the Float-Chamber and Cause Sufficient Fuel-Flow for Full Engine-Power

[1] M.S.A.E.—Chief engineer, Holley Carburetor Co., Detroit.

the fuel, thus emerging from the jet, into the engine and some of it runs out of the air entrance of the carbureter and is not available for use in the cylinders. Under identical air-flow conditions, with the conventional inverted carbureters, the fuel drawn from the jet falls into the manifold and is carried on into the engine, so the results compare very favorably with updraft practice. Examples of such downdraft installations are the Chrysler and Hupmobile designs.

Principles of Holley Carbureter

Let us now examine the construction of and the principles involved in this radically different type of downdraft carbureter, as made by Holley, to see how the fundamentally correct flow from a jet, the outlet of which is below the fuel level, has been harnessed to give a very flexible, wide-range carbureter which starts easily, accelerates positively and has become popular with the marine-engine manufacturers in so short a time.

A fact which has been known for years is that a carbureter jet the outlet of which is below the fuel level has a flow characteristic that follows the engine requirements at all speeds for wide-open-throttle operation. Fundamentally, all air-bled jet carbureters are intended to use this principle, but, owing to lack of fuel-flow when suction is insufficient to cause air to bubble through the fuel, the characteristic flow ceases and the jet becomes subject to the laws governing the flow of simple nozzles, which have been found to require an air velocity past the nozzle of approximately 1500 ft. per min. to start fuel flowing from the nozzle.

Referring to Fig. 2, curve *A* shows the characteristic flow of a jet the outlet of which is below the fuel level. We have plotted the fuel-air ratio, by weight, against cubic feet of air per minute. This follows an almost straight line over the major portion of the range corresponding to wide-open-throttle operation, with a tendency toward richness at the lower end, a fact which considerably improves the flexibility in operation of the engine and has no objectionable feature.

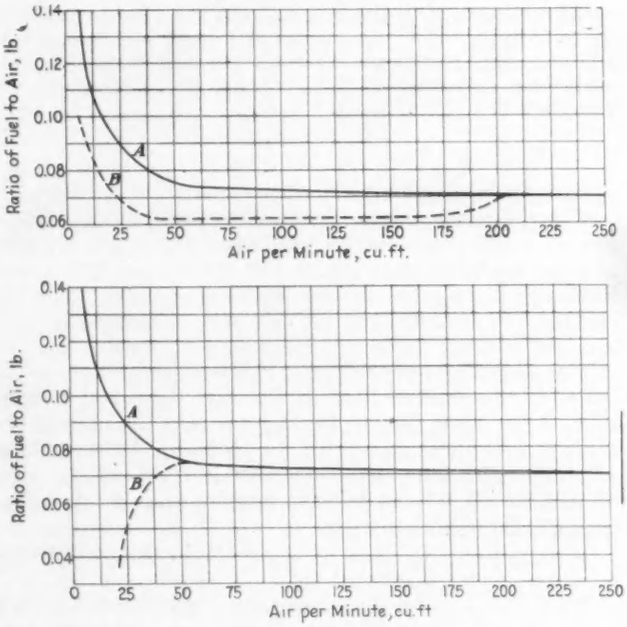


FIG. 2—(TOP) CHARACTERISTIC FUEL-FLOW FROM A JET BELOW THE FLOAT-CHAMBER FUEL-LEVEL CONTROLLED AT PART-THROTTLE BY A NEEDLE

Curve *A*, of Fuel-Air Ratio Plotted against Air Volume per Minute, Follows an Almost Straight Line over the Major Part of the Range Corresponding to Wide-Open-Throttle Operation, with a Tendency toward Richness at the Lower End, Which Improves the Flexibility of Engine Operation. Curve *B* Shows How This Characteristic Fuel-Flow Is Altered and a Progressive Throttle-Range Mixture Obtained by Means of a Needle in the Jet Which Increases the Orifice Area as the Throttle Is Opened

FIG. 3—(BOTTOM) FULL-THROTTLE MIXTURE-RATIO CURVES OF A CONVENTIONAL AND A NEEDLE-CONTROLLED UPDRAFT CARBURETER

Curve *A* Is the Same as in Fig. 2 and Curve *B* Shows the Flow of a Conventional Updraft Carbureter at Full-Open Throttle. At Low Speed and Open Throttle a Carbureter Having the *A* Characteristic Gives Good Performance, Whereas One Having the *B* Characteristic Supplies Too Lean a Mixture at an Air-Flow below 20 Cu. Ft. per Min., Corresponding to 2330 Lineal Ft. per Min. through a 1¼-In. Venturi

For the progressive throttle-range a taper needle is inserted in the jet and connected to the throttle so that as the throttle is opened the needle lifts out of the jet and increases the area of the orifice. The relation of this needle to the throttle is the idle-mixture adjustment; and, incidentally, is the only adjustment on the carbureter. The construction is so arranged that beyond three-quarter throttle-opening the taper needle is lifted clear out of the jet and allows its fundamental characteristic, as shown in curve *A*, to function. Curve *B* in Fig. 2 shows how the taper needle alters this characteristic and enables us to secure any desired progressive throttle mixture without in any way affecting wide-open-throttle conditions.

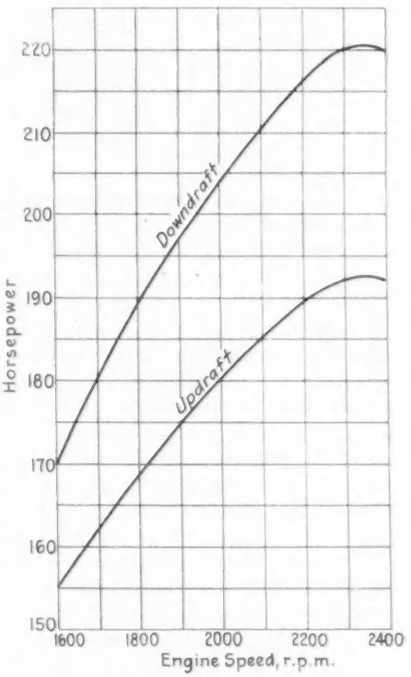


FIG. 4—POWER INCREASE OBTAINED WITH A WIDE-RANGE DOWNDRAFT CARBURETER AND CORRECT MANIFOLDING

This Increase, Which Is Over the Whole Operating Range, Is Obtained without Sacrifice of Engine Flexibility. This Is Accomplished Largely by Increasing the Volumetric Efficiency through the Use of Larger Manifolds and a Carbureter Having Greater Air-Flow Capacity and by a Reduction of Hot-Spot Area

In Fig. 3 at *B* is shown the full-throttle mixture-ratio curve of a conventional updraft carbureter of 1½-in. nominal size when such a carbureter has been "opened up" to have an air-flow comparable with the radically different type we have been discussing. The

curve *A* will be recognized as that shown in Fig. 2 and it will readily be seen why a carbureter having such a characteristic will perform at low speeds and open throttle, whereas a carbureter having the characteristic shown at *B* is lacking in jet flow below an air-flow of 20 cu. ft. per min., which corresponds to 2330 lineal ft. per min. through a 1¼-in. venturi, and the mixture becomes too impoverished to ignite.

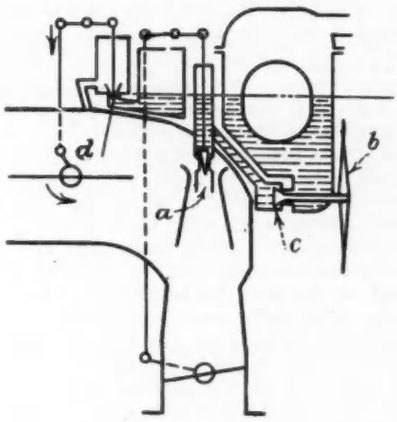


FIG. 5—DIAGRAMMATIC SKETCH OF DOWNDRAFT CARBURETER IN WHICH NOZZLE OUTLET IS BELOW FUEL LEVEL

a, Nozzle Outlet; *b*, Metal Diaphragm Controlled by Oil-Pressure from Engine; *c*, Valve To Stop Fuel-Flow When Oil Pressure Drops below 10 lb. per Sq. In.; *d*, Needle Connected with Choke for Starting Cold

Fig. 4 shows the average increase in power obtained, without the sacrifice of flexibility, by the installation of one of these wide-range downdraft carbureters with proper manifolding. Note that the increase is over the whole range; not only at the top end, as might be expected. This improvement in power is accomplished largely by increasing the volumetric efficiency through the use of larger manifolds, a carbureter that has a greater air-flow capacity, and a reduction in hot-spot area, which reduces the mixture temperature considerably below usual practice. In many cases this temperature is approximately the same as that of the air entering the carbureter when the engine is developing the maximum horsepower.

A diagrammatic drawing of this new and different downdraft carbureter is given in Fig. 5. Observe that the nozzle outlet *a* is below the fuel level in the float-chamber. At *b* is a metal diaphragm, controlled by oil pressure from the engine, which closes valve *c* and stops the fuel-flow whenever the oil pressure falls below 10 lb. per sq. in., thus preventing any leak when the engine is not running. Obviously, no oil pressure is available when starting from cold; however, provision has been made so that when the choke is closed a needle, *d*, is opened and fuel is transmitted by suction direct from the float-chamber to the mixing chamber and thence to the manifold.

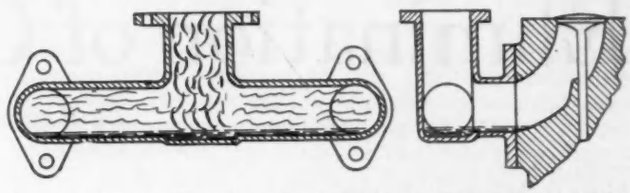


FIG. 6—LARGE-DIAMETER MANIFOLD FOR DOWNDRAFT CARBURETER

When Starting a Cold Engine, Liquid Fuel Collects at the Bottom, but a Large Space Transmits an Atomized Charge from the Carbureter to the Inlet Valve. The Atomized Fuel Does Not Have To Bubble up through Liquid Fuel, as with an Updraft Carbureter

Large-Area Manifold Advantageous

Some question has been raised regarding correct manifolding for these carbureters. Our experience has shown that the cross-section area of the manifold branch can be 50 per cent larger than the actual valve opening and that distribution is easier to obtain with downdraft carbureters and such a manifold than would be possible with updraft carbureters and a similar manifold cross-section.

Furthermore, with downdraft carburetion it is possible to arrange the hot-spot so that the fuel falls by gavity onto the heated surface, which preferably takes the form of a shallow pocket, making unnecessary the heating of the air portion of the charge by surrounding the manifold with a heat jacket, except for rapid warming up.

In starting a cold engine, the heavy fuel goes to the bottom, leaving a large area above for the transmission of an atomized charge from the carbureter to the inlet valve, as shown in Fig. 6. The space above the solid fuel can be utilized until the manifold becomes well filled with liquid fuel. A start should be made before the manifold does fill up, our experience being that, with our system of having a starting-jet supply separate from the normal running jets, correct starting-mixture proportions are readily available and we are able to secure positive starting in a few seconds. With an updraft carbureter, any atomized fuel has to be bubbled through a mass of liquid gasoline unless the engine starts instantly, for in 10 sec. of cranking at low engine revolution the carbureter and riser fill up with liquid fuel.

Elimination of Chassis Vibration

By EARL H. SMITH[1]

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS

AFTER all moving parts of the chassis are perfectly balanced, vibrations that are disagreeable to the occupants of an automobile still remain. Almost all of these emanate from the engine, and a method of mounting the engine so as to reduce the transmission of vibration from it to the frame was the problem that presented itself at the time the development of a mounting began.

Rubber was selected as the ideal material for the engine mounting, but a design that would absorb the vibrations and still maintain engine stability when driving over rough roads remained to be perfected. Rubber blocks of various shapes were tried until a truncated-pyramid type gave promise of excellent results. This rubber block was 1 in. high and 2¼ x 4¼ in. in its lateral dimensions. The longer dimension was placed crosswise of the car, which afforded horizontal engine-stability. A bolt was passed through the mounting and the engine leg to provide vertical engine-stability. This bolt was insulated from the engine leg by a soft-rubber collar. The front of the engine was found to be less sensitive to a rubber mounting, hence rubber washers were used there to separate the engine from the frame. A through bolt was again used to provide vertical stability.

A device by which the vibrations in the engine and frame could be measured electrically was perfected, and with the engine mounted directly on the frame three times as much vibration was found in the frame as in the engine. The rubber mounting reduced the frame vibration to one-sixth of its original value, with the vibration in the engine remaining the same. This mounting has been in use for two years and has given no difficulty in that time.

THE first fundamentals for obtaining a quiet chassis are correct balance of the rotating and the reciprocating parts, such as propeller-shafts, crankshaft, flywheel, clutch, pistons and connecting-rods. After all of these units are carefully designed and balanced so as to eliminate vibration due to rotation, a number of sources of vibration still remain, such as crankshaft torsion, engine roughness resulting from combustion-chamber design and compression ratio, and the vibrations as transmitted from any piece of moving machinery, regardless of how well it is built, to which the chassis might attune itself.

This paper will deal with the prevention of the transmission of vibrations from the engine to the chassis and is a non-technical description of work carried on during the last three years to reduce to the minimum the transmission of vibration at this point in the car. While many theories on the use of elastic materials to absorb vibration have been evolved, only one was investigated as to its application to the problem. The Insulation of Vibration, by Vern O. Knudsen, of the University of California, was selected and in it was found the very interesting fact that the relationship of the elasticity to the dampening coefficient of the mounting material affected the absorption of vibration and in certain parts changed the absorption to amplification.

In a first analysis of the elimination of transmission of vibration from the engine, two methods were presented: (*a*) mounting the engine on springs and (*b*) mounting the engine on rubber. The first method was arbitrarily eliminated and activities were confined entirely to rubber. The initial set-ups consisted of mounting the engine very flexibly on large blocks of rubber at all four points of suspension, the engine being on a four-point mounting. These blocks of rubber were in compression and, when a sufficient mass of rubber was introduced, the effect was immediately noticeable in the reduction of the transmission of vibration.

Tension or Compression Type of Mounting

In attempts to further the effectiveness of the absorption of engine noises, we tried rubber in tension, which was not successful with the designs available at the time because of the magnitude of engine movement when driving over rough roads. All activities were therefore concentrated on the compression type of mounting. Engine mountings are undoubtedly available today in which the rubber in tension gives satisfactory results, but our compression type has been so satisfactory that we have conducted no work on the other.

Among the compression types of mounting tried were large blocks of rubber on which the engine rested and was held down by a bolt passing directly through the rubber or by studs embedded in each side of the rubber block. Other mountings tried consisted of flat pancake types in which the height of the rubber was small in relation to the lateral dimensions. All of these mountings allowed too much engine movement, those without the through bolt allowing both vertical and horizontal movement and those with the bolt-holddown construction allowing too much horizontal movement.

The excess movement of the engine was very undesirable because it manifested itself through excessive movement of the gearshift and brake levers, the clutch and the brake pedal, all of these units being mounted with the powerplant. In addition to this, however, excessive engine-movement caused crystallization of the gasoline lines and of the exhaust pipe and also caused difficulty with breakage of the top tank of the radiator where the inlet hose to the radiator transmitted the engine movement to the radiator core.

The fundamental problem then presented itself of developing a mounting of the compression type which

[1] M.S.A.E.—Assistant chief engineer, Olds Motor Works, Lansing, Mich.

had a sufficient mass of rubber so that, with a specified unit-pressure on the rubber, hardness would not build up to such an extent that excessive vibration was transmitted and also with the rubber so disposed of that more than normal engine movement would be eliminated. After analyzing the various types of mounting tried, we realized that a successful compression mounting must have a large area of contact with the engine and with the engine bracket on the frame so as to reduce the unit stress in the rubber, and also that this area of rubber must be disposed of so as to prevent engine movement due to driving over rough roads.

Developing a Satisfactory Mounting

Conical types of mounting, with the rubber in compression, were tried, but eventually we evolved the present Olds mounting in which a piece of rubber in the shape of a flat-topped pyramid is utilized. The engine leg enclosed the top and the sloping faces of the block. The vertical thickness of rubber was 1 in. and the horizontal dimensions were 2¼ x 4¼ in. The block was a truncated section of a pyramid and the longer of the two lateral dimensions was placed crosswise of the car. This was done because we found by many road experiments that the engine did not need as much rubber in the front as in the rear and, with a very small mass of rubber in the front, the front of the engine was comparatively rigidly mounted as far as horizontal movement was concerned; therefore the only possible movement of the rear of the engine in a horizontal direction was crosswise of the car as the engine tried to swing in a circle in a horizontal plane around its front mountings.

Horizontal stability thus being gained, thought was given to vertical engine-stability. A bolt was passed through the engine leg, the rubber mounting and the frame bracket and was insulated on the upper side of the engine leg by a rubber collar and with excessive clearance where it passed through the engine leg. The bottom of the bolt passed through a flange under the frame bracket which prevented the bolt from moving laterally. The entire design did not allow any metal contact between the engine and the frame, as can be seen from Fig. 1.

Minor refinements in the rubber were worked out in the form of cavities on the bottom face to serve as air chambers. Corrugations in the engine leg where it fitted over the rubber block also helped. Both of these changes were of value in increasing the efficiency of the mounting by making it absorb more vibration. The front mounting consisted merely of rubber washers upon which the engine rested and with a through bolt that was carefully insulated from the engine and the frame so that again no metallic connection was present. This design is illustrated in Fig. 2.

Experiments were then conducted in developing a degree of hardness in the rubber that would render it the most effective vibration-absorbent, and in determining how tight the bolt should be which passed through the mounting. At this phase of the development we found ourselves working with such minor improvements in absorption of vibration that we had to develop a means of actually measuring the vibration absorbed by the rubber.

The General Motors Corp. Research Laboratories was consulted and the result was an electrical device by which the vibration of the engine and the frame could be measured in electrical units, thereby eliminating the human element in judging the roughness of the car as presented by engine vibration transmitted to the frame. The apparatus consisted of two identical electromagnetic vibration-pickups, an accurate potential-divider and a vacuum-tube amplifier-detector. Two switches were built in with the divider to facilitate the measurement. Each of the two pickups consisted of a Baldwin Rival loud-speaker unit, with a specially loaded diaphragm, mounted in a strong and dust-proof case. A very accurate potential-divider was obtained by interlocking two Leeds & Northrup resistance boxes so that the sum of their resistance was constant. The amplifier consisted of three stages of resistance-capacity coupled units, with a voltage multiplication of about 3000, or in other words a radio-amplifying unit.

Vibration Measured Electrically

A very rough analogy can be drawn by comparing the two electromagnetic pickup devices and the two resistances of the potential divider to the four legs of a Wheatstone bridge, with the radio-amplifying unit taking the place of the galvanometer unit of the bridge circuit. The two electromagnetic units were clamped to the engine leg and the frame adjacent to the engine leg respectively, and a torsional vibration was introduced into the crankshaft at its fundamental frequency by a vibrating unit attached to the front end of the shaft.

This unit was a device of conventional type for instigating torsional vibration and consisted of a number of out-of-balance gears mounted in a casting that was attached to the crankshaft, the gears rotated at the desired speed. By this means mountings could be placed under the engine and checked accurately in a short time as it was only a matter of a simple laboratory set-up to determine the effectiveness of the mounting by balancing the potential divider so that the reading obtained on a micro-ammeter measuring the flow of *B*-battery current in the radio amplifier was the same for each pickup device. The potential divider, of course, was adjusted to make the flow of the *B*-battery current the same for any two readings, and the ratio of the two resistances was the ratio of vibration in the engine to that in the frame.

The readings of the ratio of resistance was 3 to 1 with the engine mounted rigidly with metal-to-metal contact on the frame, and the mounting as finally developed reduced this ratio to the proportion of ½ to 1. An analysis of these readings shows that, with the particular chassis used the vibration in the frame was three times that in the engine when the engine was mounted with a rigid metal-to-metal contact. Rubber in the mounting reduced the frame vibration to one-sixth of its former value, with that in the engine remaining constant.

The vibration-pickup units when transferred to the front of the engine, one being mounted on the engine leg and one to the frame adjacent to the leg, showed no appreciable difference in effect between a very small and a large mass of rubber in the mounting. This verified our findings on the road.

Various Rubber Combinations Tried

With this set-up experiments were then conducted on the truncated-cone type of rear mounting with various rubber combinations and degrees of hardness ranging

from very soft to a fairly hard rubber. Based on the analysis of insulation of vibration by Mr. Knudsen, we attempted to develop a mounting having various hardnesses of rubber, each of which would absorb a certain range of vibration frequencies. This was the fundamental cause for trying laminated rubber and combination mountings, such as a type in which the center was of extremely soft rubber and the exterior of a harder composition. A number of mountings of this type were developed, some having as many as seven laminations of rubber, each ⅛ in. thick and of different hardness; also mountings of consistent hardness varying from the softest to the hardest rubber permissible to use. The effect of tightening the holddown bolt passing through the mounting was also worked out with each type of mounting, and we found that this bolt was most effective when it was first tightened with the fingers and subsequently with the wrench to approximately one turn of the nut.

Mountings with rubber of 32 Durometer hardness, with rubber of 69 Durometer hardness, with laminated rubber of alternate layers varying from 32 to 69 hardness, and a mounting having a core of 32 Durometer hardness and a shell of 69 Durometer hardness, were selected from the large number tried in the laboratory as the most promising for road trial.

These four types of mounting were then installed in a number of cars and observed for transmission of engine vibration to the chassis by various individuals and were graded by these individuals without their knowledge as to the type of mounting in the car. The soft-rubber mounting of 32 hardness was found to allow too much engine movement, and the combination mountings made from varying hardnesses of rubber were found no more effective than the mounting made of 69 Durometer hardness of rubber because the periods of the frame that tuned to the engine vibrations were such that the 69 hardness of rubber absorbed the vibrations that were disagreeable to the occupants. Consequently, activities were confined to the truncated-cone type of mounting with a rubber having a hardness of 69 Durometer and that, when compressed 50 per cent and heated to 100 deg. fahr. for 24 hr. and then cooled, took a permanent set of only approximately 8 per cent. A washer-type front-mounting of the same hardness as the rear mounting was tried and proved very effective.

Eliminating the Weak Points

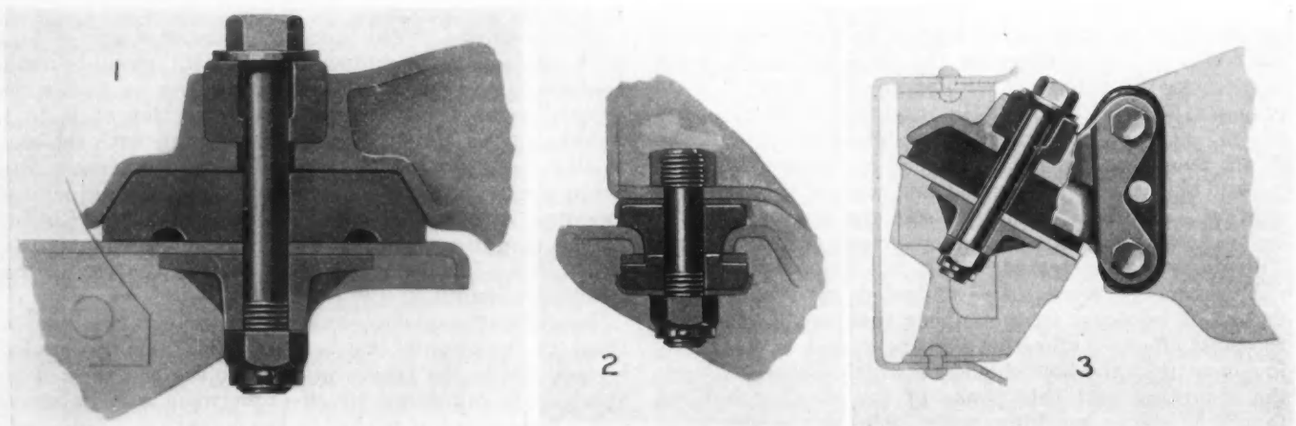
The sensitiveness of the tightness of the through bolt of the mounting was next attacked, and by reverting to the laboratory set-up we found that this sensitiveness could be greatly reduced by making the upper rubber-collar used on top of the rear engine-leg with a counterbore and of 32 Durometer hardness. This changed the sensitiveness of tightness of the bolt from one turn tight with a wrench to four turns, which was very desirable as regards production and, as we thought at that time, from the standpoint of adjustment while in service. The latter, however, was a needless worry because, over a period of 25,000 miles of use, the rubber mounting took only so much permanent set as could be measured by one-half turn of the through bolt.

The other questionable factor in the mounting, that of rubber deterioration, was proved over a period of two years, in which time we found that the rubber did not deteriorate sufficiently to cause any noticeable change in 50,000 miles of travel.

This type of mounting has now been in use for two years by the Olds Motor Works and is in its third year. However, in adapting it to a different type of engine in which the relation of the center of gravity to the point of mounting was changed in a vertical plane, we found it necessary to place the mounting at an angle of 30 deg. with the horizontal to maintain engine stability over rough roads. This change in the angle of the mounting, which is shown in Fig. 3, did not exert any appreciable effect on the vibration absorption powers of the device.

In every case, however, of trying a rubber mounting on an engine, redesigning the frame to afford sufficient frame-stability was found necessary, because the engine did not provide the additional stiffness when mounted on rubber. After much development work on this subject, the conclusion was arrived at that the frame movement caused by rubber mountings was hori-

(*Concluded on p.* 162)



EXAMPLES OF RUBBER ENGINE-MOUNTINGS THAT HAVE BEEN DEVELOPED TO ELIMINATE TRANSMISSION OF VIBRATIONS FROM THE ENGINE TO THE CHASSIS

Fig. 1—Original Truncated-Pyramid Type of Rear Mounting in Which the Engine Leg Enclosed the Top and the Sloping Side-Faces of a Rubber Block 1 In. High, 2¼ In. Long and 4½ In. Wide. Fig. 2—Washer-Type Front-Mounting. Fig. 3—Revised Form of Rear Mounting Which Is Placed at an Angle of 30 Deg. with the Horizontal To Maintain Engine Stability on Rough Roads. In All Three Types a Through Bolt Is Used To Provide Vertical Engine-Stability

Cold Carburetion

By CARL H. KINDL[1]

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND DIAGRAMS

EXPERIMENTS made and methods employed to obtain satisfactory engine operation without the addition of heat to the fuel-air mixture are described, as it is known that the power output of an engine is greater as the temperature of the mixture is lower and that higher compression can be used with lower mixture-temperature.

The work was initiated with a single-cylinder engine in which kerosene was used as a fuel to ascertain the results that could be obtained without vaporizing the fuel in the manifold, the liquid being added to the air in the valve-chamber as the air entered the combustion-chamber.

As satisfactory results followed, the next step was to devise and apply a mechanism based on the same principle to a multi-cylinder engine. The first and succeeding carbureter-manifold combinations used are illustrated and described. The basic idea in these is the provision of small-diameter fuel manifolds or tubes in which a small volume of air is admitted to carry the fuel from the carbureter orifices to the valve ports, and large-diameter manifold tubes for the main air-supply to the cylinders. Very little vaporization occurs in the manifold. Throttles are placed in both the air and the fuel manifolds.

Experiments were made using a glass main-manifold and a neon-tube stroboscope for observation of the action of the fuel-flow and mixture distribution. Sufficiently good distribution was obtained with one fuel-orifice for each pair of cylinders of a six-cylinder engine, but a jet for each cylinder and individual valve-ports are suggested as likely to give most perfect distribution.

Details of the carbureter and the throttles are given, together with their action when idling and when accelerating. The obtaining of precisely equal fuel-flow from the three orifices presented an intricate problem, owing to air eddies and unequal pressures in the carbureter. Another important problem was presented by the difficulty of obtaining prompt acceleration.

Application of the cold-carburetion system to an engine is comparatively simple, as no connection is made with the exhaust manifold. It is desirable to considerably separate the intake system from the exhaust manifold to keep the air temperature low. Better results were obtained from the system applied to an overhead-valve engine than to an engine of the L-head type.

Cold-carburetion still involves some difficult problems and the final results of this development cannot safely be predicted, but the advantages are so great that the author believes that cold carburetion should soon become commercial practice.

MEANS for obtaining the maximum power from a fixed engine-displacement is one of the present problems confronting engine designers. Considerable progress made recently in combustion-chamber design has made possible the use of higher compressions without increasing detonation, thereby obtaining increased engine-power. Carbureter engineers have contributed to this progress by improved manifold-design for better distribution throughout the induction system. Duplex manifolds and double carbureters are used on most eight-cylinder engines to gain engine power; however, one glaring inconsistency is the application of heat to the intake gases.

The general equation for power in an internal-combustion engine involves the temperature of the mixture entering the cylinder. To just what extent this temperature coefficient enters into the result depends upon several other factors, but it is always true that the power of an engine increases as the temperature of the mixture entering the cylinder decreases. With this decrease in temperature, it becomes possible to increase the compression and thus afford still greater gain in output.

It is well known that a definite mixture-temperature is necessary with the conventional carbureter, so that the fuel will combine with the air in the manifold and result in furnishing the correct ratio of air to fuel in each cylinder; in other words, good distribution is assisted by the application of heat. Therefore the problem is to design a system that will give the correct distribution of fuel and air without the use of heat. Such a system would have other advantages besides increased power, one important benefit being the short time required to operate an engine from starting under winter conditions without excessive use of the carbureter choke. Since good distribution would be obtained without heat, no warming of the manifold would be necessary as with present systems.

Methods Used in Early Work

The first work done was to use kerosene for fuel to determine what results could be obtained without vaporizing the fuel in the manifold. A single-cylinder engine was used, and it was found that liquid fuel added to the air entering the combustion-chamber would produce satisfactory results. This fuel was added to the air in the valve chamber, and probably some of it was vaporized before it entered the combustion-chamber. The next step was to apply the combination to a multi-cylinder engine.

One of the early manifold designs used on a six-cylinder engine in this work is shown at the top in Fig. 1. The intake ports were siamesed in pairs, and fuel was furnished through a separate tube to each valve port. A throttle was placed in each manifold leg and these were coupled together for single control. It was found

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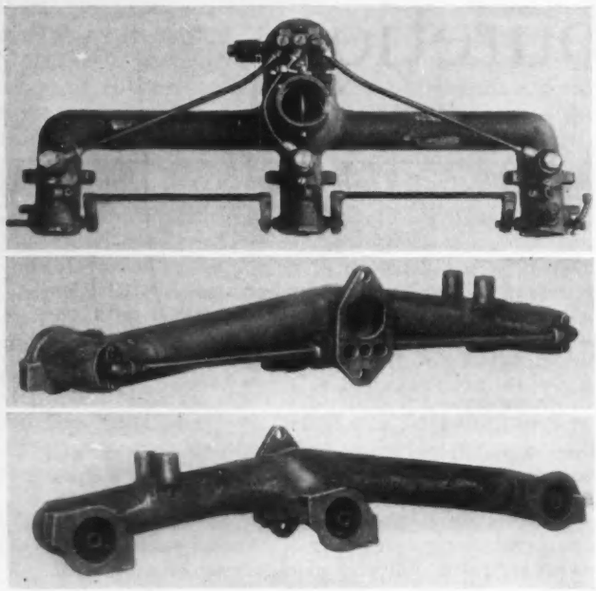

FIG. 1—(TOP) EARLY DESIGN OF CARBURETER AND MANIFOLD USED ON A SIX-CYLINDER ENGINE. (BELOW) TWO VIEWS OF MANIFOLD USED FOLLOWING THE ONE ABOVE

necessary to connect the three valve-ports with a common tube to equalize pressures before uniform distribution was obtained. Promising results were given by this device, but much difficulty was experienced with the mechanism of the three throttles, owing to their wide distance apart and to mechanical changes resulting from engine temperatures. When the engine was not horizontal, as in climbing a long grade, the flow from the orifices was not equal because of the variation in head; but this objection was overcome by locating the orifices at the float bowl, so that the tubes carried fuel and air.

The manifold shown in two views below in Fig. 1 was then used. Fuel is delivered to the cylinder through small tubes, of 5/16 to 9/16-in. diameter, depending on the size of the engine. Air is added to the fuel merely as a means of moving the liquid, since very little vaporization occurs. Fig. 2 shows a diagram of this manifold and carbureter. Throttles are placed in both

TABLE 1—EXHAUST-GAS ANALYSIS WITH A COLD CARBURETER

Conditions—Spark Advance, 36 Deg.; Engine Speed, 1212 R.P.M.; Brake Load, 35.9 Lb-Ft.; Barometer, 29.44 In.; Room Temperature, 86 Deg. Fahr.; Inlet and Outlet-Water Temperatures, 164 and 172 Deg. Fahr., Respectively

Cylinder No.	Content, Per Cent		
	CO_2	O	CO
1	14.4	0.2	0.4
2	13.8	0.2	0.8
3	14.2	0.4	—
4	14.2	0.4	0.8
5	13.8	1.0	—
6	13.4	1.4	—

the air and the fuel manifolds, respectively referred to as the main and the primary manifolds. It is assumed that both throttles are open wide and that they do not affect the discussion. The primary-manifold tubes are maintained separate from one another for some distance beyond the orifices. Each orifice supplies its tube with fuel and all operate under the same head. The tubes are filled with a super-rich mixture and, at low speeds or at low air-velocities, the fuel flows as a stream in the lower portion of the tubes.

Glass Manifold and Stroboscope Used

Experiments were made using a glass main-manifold and a neon-tube stroboscope. The action is that, when a cylinder valve opens during the suction stroke, air rushes into the port and fuel is discharged from the primary tube. As the piston reaches the end of its stroke, the rush of air and fuel ceases. This repeats itself during the suction stroke of the cylinder sharing the siamesed valve-port, but no fuel-flow is apparent in this portion of the manifold while the cylinders of the other valve ports are having their suction strokes; however, flow is practically continuous at the orifices, but the tubes deliver fuel only during the suction stroke. Thus a proper mixture is obtained in each cylinder. Table 1 shows a sample exhaust-gas analysis obtained with the carbureter and manifold.

Action of Carbureter and Throttles

Fig. 3 shows a vertical section through the center of the carbureter and manifold, the stippled portion indicating the path taken by the fuel. Liquid fuel comes from the orifice, on account of the drop in pressure un-

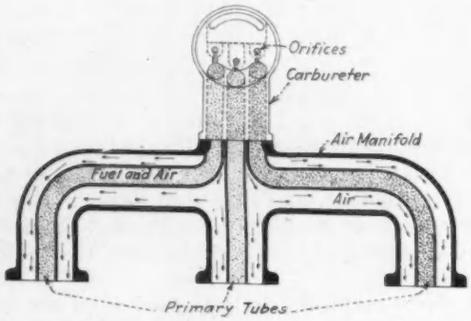

FIG. 2—DIAGRAM OF MANIFOLD SHOWN BELOW IN FIG. 1, WITH CARBURETER ATTACHED

Throttles Are Placed in Both the Air and the Fuel Manifold, Referred to Respectively as the Main and the Primary Manifolds

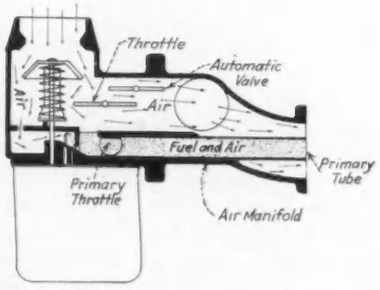

FIG. 3—VERTICAL SECTION THROUGH CENTER OF CARBURETER AND MANIFOLD

The Stippled Portion Indicates the Path Taken by the Fuel, the Main and Primary Throttles Being Wide Open

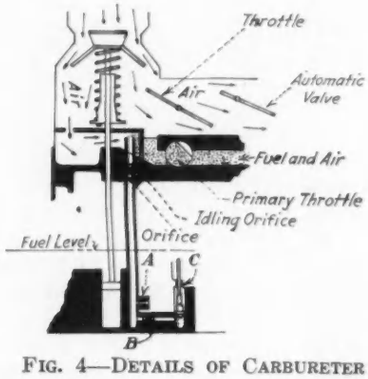

FIG. 4—DETAILS OF CARBURETER

A Part-Throttle Orifice, *A*, in the Main Tube from the Fuel Bowl, Has a Slight Control of the Fuel-Flow. Orifice *B* Controls the Power Mixture. Needle *C* Is for Open-Throttle Operation

der the air valve, and is picked up by the air in the primary manifold. After leaving the orifice, the fuel is conducted along a horizontal or a downward sloping path to the valve port, thus affording no occasion for the air to lift the fuel. An orifice is provided for each pair of cylinders, and each orifice is contained in its individual chamber as shown. Individual valve-ports and a jet for each cylinder are naturally suggested for the ultimate in perfect distribution; but it was found that sufficiently good distribution was obtained with one orifice per pair of cylinders, and this was continued on account of simplicity.

During the idle setting of the carbureter, the main throttle is closed and practically all air is taken through the primary throttle. This results in high velocity through the small manifold and prevents loading and puddling at this throttle setting. At low part-throttle speeds, the main throttle remains closed as at idle setting, and the primary throttle opens. The engine thus runs with a small manifold, which results in several advantages. As the accelerator is opened further, the main throttle follows to the open-throttle position, as shown. The calibration of the carbureter is accomplished entirely by controlling the shape of the air valve, and operates throughout the entire range.

Other details of the carbureter are shown in section in Fig. 4. The three main-jets are supplied by a common tube from the fuel bowl. This tube contains a part-throttle orifice, *A*, which has a slight control of the fuel-flow. Orifice *B* controls the power mixture, which is brought into effect by the needle, *C*, for open-throttle operation. The carbureter is comparatively simple from the viewpoints of calibration and metering, and provides mixture-ratio control for maximum economy and power operation.

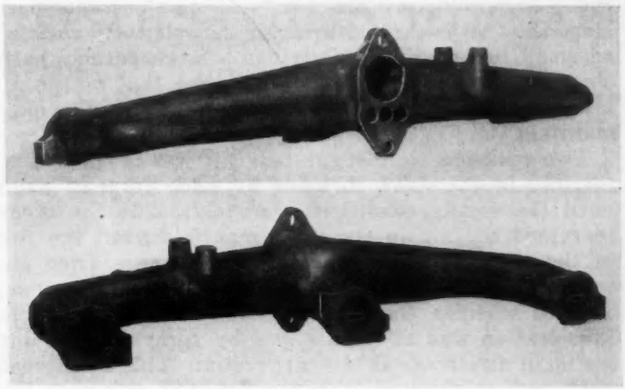

FIG. 5—SIX-CYLINDER MANIFOLD IN WHICH THE PRIMARY TUBES ARE CAST WITH THE MANIFOLD

The Tubes Are Flattened To Avoid the Possibility of Loading by Having Fuel Collect in the Bottom

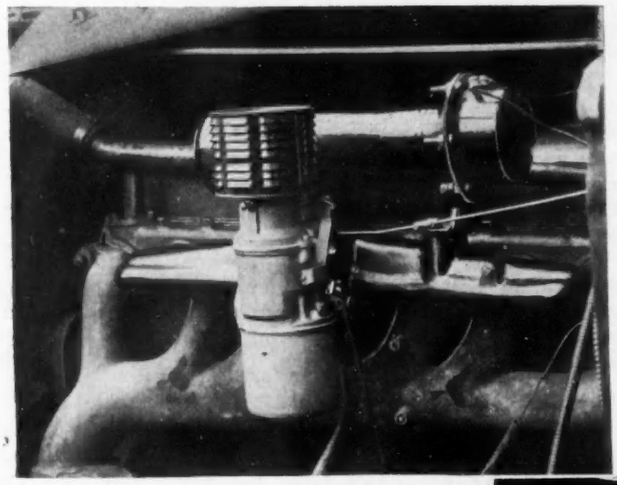

FIG. 6—SIMPLICITY OF APPLICATION OF COLD-CARBURETION SYSTEM TO AN ENGINE

Orifice-Flow and Acceleration Difficulties

One of the most intricate problems was to obtain a design in which the three orifices for the six cylinders would produce exactly similar flow. It is not merely a matter of physical dimensions of the orifices, but the movement of the air through the carbureter causes eddies and unequal pressures in various portions of its parts, and these variations in pressure result in unequal flow from the orifices, which would cause poor distribution and poor economy. The shape of the carbureter and the location of the main orifices were determined after a long series of experiments.

Another important problem was presented by the difficulty in obtaining acceleration. When both the primary and main throttles are suddenly opened from the idle position, air rushes through the main manifold to

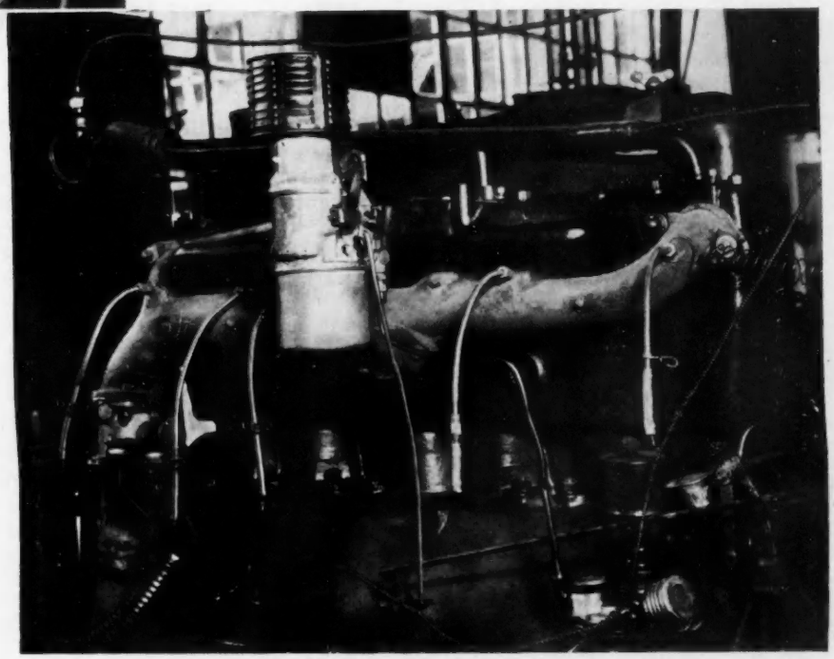

FIG. 7—COLD-CARBURETION SYSTEM AS APPLIED TO AN ENGINE USED FOR LABORATORY TESTS

the cylinders before the fuel reaches the valve port, since the fuel is carried through the relatively restricted small tubes while the air has a large parallel path. The weight of the fuel compared with that of the air also tends to make it lag behind the air in the main manifold.

Two solutions were suggested. One was to supply fuel forcibly to the valve chamber by some form of pump until the steady conditions were obtained; the other, to retard the air in the main manifold until the fuel in the primary tubes traveled the distance from the orifices to the cylinders. Although much time was spent on both schemes, the latter solution seemed preferable. Acceleration was attempted also by spraying fuel into the main airstream at the carbureter. This functioned fairly well in warm weather but failed at extremely low temperatures on account of the poor distribution of the accelerating fuel. This was equivalent to the conventional means of accelerating with the usual carbureter, and was about as successful as the conventional carbureter would be without heat.

If the main-mainfold throttle is held closed and the primary throttle is opened suddenly, the velocity in the small-diameter tubes is sufficiently great to carry the fuel with the air under cold temperatures. The diameter of the primary tubes is determined by this low-temperature condition. The main throttle can then be opened slowly at a rate to afford the correct mixture ratio at the cylinders, this being provided by the automatic throttle-valve located on an off-center shaft between the engine and the main throttle and which opens under the pressure of air against it. The automatic throttle is connected with a dash-pot in the fuel bowl which controls the speed of opening. At low engine-speeds it opens rather slowly, because of the small amount of air required by the engine; but when the accelerator is opened suddenly at high speeds, the automatic throttle opens very rapidly. The time-lag caused by the automatic throttle at high speeds is of such short duration that no appreciable time is lost in acceleration, and it prevents the sudden jerk experienced upon kicking open the accelerator of a conventional carbureter.

Fig. 5 shows a six-cylinder manifold in which the primary tubes are cast with the manifold. The tubes are flattened to avoid the possibility of loading by having fuel collect in the bottom.

Effort Concentrated on Overhead-Valve Engine

Application of the cold-carbureter system to an engine, as illustrated in Fig. 6, is comparatively simple because no connection is made with the exhaust manifold; in fact, considerable separation of the exhaust manifold from the intake system is desirable, to keep the intake-air temperature low and thereby obtain the greatest power gain.

Experiments were conducted on both L-head and valve-in-head engines. Some difficulty was experienced with loading in the L-head-engine valve-ports, because the liquid fuel collected at low open-throttle speeds. Although this trouble was overcome, certain complications were necessitated. The more favorable results obtained on overhead-valve engines resulted in the concentration of effort on them and in temporary cessation of work on the L-head design.

It is difficult to predict what the final result of this development will be. The system of cold carburetion involves some difficult problems, but the advantages are so great that cold carburetion should soon become commercial practice.

Elimination of Chassis Vibration

(*Concluded from p.* 158)

zontal movement of the frame at the front end, and in each instance this has been successfully reduced to the minimum by adding lateral stiffness to the frame in the form of increased width of the horizontal flanges of the side-rails.

In conclusion we can state that the disagreeable engine noises which make themselves evident in a car by being transmitted to the frame can be successfully eliminated by mounting the engine on rubber in compression, provided the rubber is disposed so as to prevent disagreeable engine-movement and that the hardness and volume of the rubber are such that it absorbs the vibrations the frequencies of which are in tune with the critical periods of the chassis.

Detonation Characteristics of Some of the Fuels Suggested as Standards of Antiknock Quality

By JOHN M. CAMPBELL[1], WHEELER G. LOVELL[2] AND T. A. BOYD[3]

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPH, DRAWING AND CHARTS

WHATEVER method is employed for measuring the detonation characteristics of fuels, some reproducible reference fuel or scale of fuels is needed. Reference fuels are needed to assure dependability of results and to provide a common basis of comparison between different laboratories. The fuels should be of definite chemical composition so that they can be reproduced with certainty at any time.

It is not the function of this paper to recommend the specific fuels that should be selected as standards of antiknock quality, but rather to present quantitative data on the detonation characteristics of some of the individual fuels that have been suggested. Such data are here presented in terms of compression ratio for incipient knock over the entire range of composition from zero to 100-per cent concentration, as determined in admixture with normal heptane.

Normal heptane seems to be the only one of the several fuels included in this survey that has a sufficient degree of tendency to knock to make it suitable to form the lower limit of a scale of antiknock quality consisting of two pure fuels mixed in various proportions, one of low and one of high antiknock quality. Of the fuels from which a selection might be made for the upper limit of such a scale, there are cyclohexane, iso-octane, benzene, toluene and alcohol, each having certain advantages and disadvantages, some of which are discussed.

THE THREE principal requirements of any system of measuring the antiknock quality of a gasoline are (*a*) a standard engine, (*b*) a standard procedure, and (*c*) a standard fuel. Items (*a*) and (*b*) are necessary because the tendency of a given fuel to knock may depend in a large measure upon the design of the engine in which the fuel is burned and the conditions under which the engine is operated. Even the relative tendency of one fuel to knock with respect to that of another may depend to some extent upon the factors of design and the conditions of operation.

Whatever method of knock rating is employed, a standard fuel is required both to provide a common basis of comparison between the observations of different laboratories and to furnish a definite means of keeping the knock ratings of any individual laboratory on a uniform basis. If, for instance, antiknock quality is measured in terms of compression ratio for a definite degree of knock in a certain engine and under given conditions, a standard fuel offers the only definite or altogether reproducible basis for checking the mechanical condition of the engine from time to time. Likewise, if antiknock quality is measured in terms of operating variables, such as throttle opening or spark advance for a definite degree of knock in a certain engine under given conditions, a standard fuel offers the only means of definitely standardizing the mechanical condition of the engine.

Another use for a standard fuel is found in connection with those methods of measurement which express antiknock quality directly in terms of the chemical composition of some reference fuel. Thus, the antiknock quality of a fuel is sometimes expressed in terms of the amount of some knock suppressor or knock inducer that must be added to a reference gasoline to produce a fuel having the same tendency to knock under definite conditions as has the fuel under examination. But the only definite and positively reproducible means of checking the antiknock quality of the reference fuel, after long periods of storage and as new stocks are added to replace those exhausted, is by means of some standard fuel of definite chemical composition which can be exactly duplicated at any time.

Still another use for a standard fuel is found in those methods of knock rating in which the antiknock quality of a fuel is expressed in terms of changes in the composition of the standard fuel itself. Such a standard fuel is really of variable composition and may consist of a mixture of two fuels of widely different antiknock qualities that can be mixed in the right proportions to match the antiknock quality of any fuel which it may be desired to rate. The particular advantage of this method of expressing antiknock quality is that, when the two components of the standard fuel are pure substances, it is possible to establish antiknock specifications which are reproducible to an exact degree by anyone and at any time or place, provided the equipment and operating conditions are maintained reasonably uniform. This is true irrespective of whether measurements of detonation are made by ear or by means of some form of instrumentation.

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[2] Assistant head of fuel section, General Motors Corp. Research Laboratories, Detroit.

[3] M.S.A.E.—Head of fuel section, General Motors Corp. Research Laboratories, Detroit.

Requirements for Standard Fuels

It is apparent that, as already said, any fuels which are used as standards of antiknock quality should be of definite chemical composition so that they can be reproduced at any time. One way of meeting this requirement definitely is to make the standard fuels out of pure substances that can be mixed in known quantities. A gasoline is not a suitable standard because it cannot be reproduced in antiknock quality to an accuracy greater than the experimental error in matching fuels. This process involves the possibility of a cumulative error to such an extent that, after several successive restandardizations, the reference gasoline might conceivably have a knock rating appreciably different from the original.

Further, gasolines, and especially cracked gasolines of high antiknock quality, are not suitable for standard fuels because of their tendency to change their knock rating in storage. It is desirable, however, that the standard fuel be as nearly like gasoline as possible in its physical and chemical properties. It should be composed of definite materials that are available in sufficient quantities to meet the widespread demand for a standard fuel. Finally, to serve as a standard of variable composition, it should be composed of substances which, when combined in various relative percentages, can be made to duplicate the antiknock quality of the entire range of gasolines that have to be rated.

Although a number of chemical compounds exist which meet some or all of these requirements for a standard of antiknock quality, no comprehensive data on the relationships that they bear to one another have been published; consequently, it has been thought worthwhile to present some quantitative data on the detonation characteristics of several of the more common individual compounds that have been considered, and to make these data cover the entire range of composition from zero to 100-per cent concentration of each. Such data are presented in this paper, and the principal compounds are discussed from the viewpoint of their suitability for preparing a standard fuel-mixture of variable composition that can be made to match the antiknock quality of any commercial fuel.

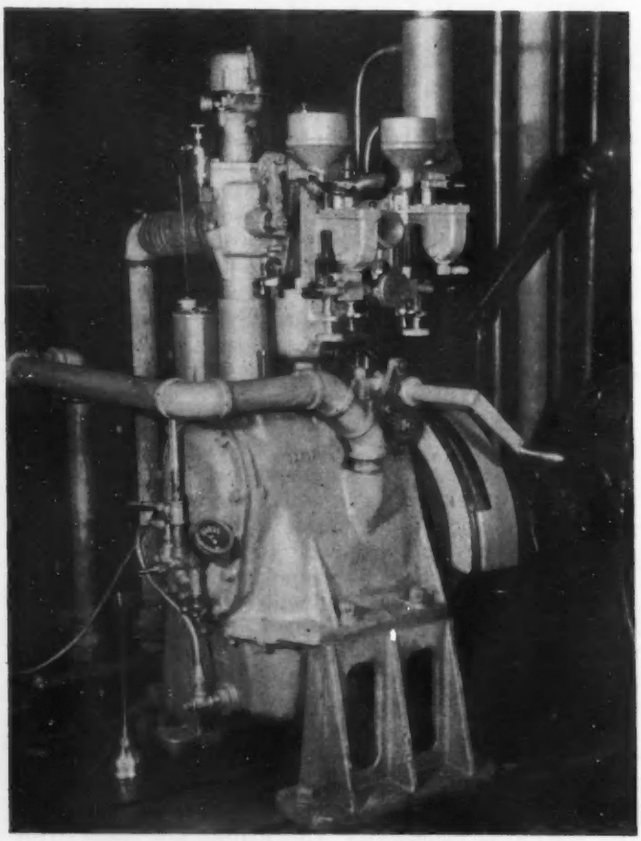


FIG. 1—SINGLE-CYLINDER VARIABLE-COMPRESSION ENGINE USED FOR DETERMINING THE RELATIVE DETONATION CHARACTERISTICS OF FUELS

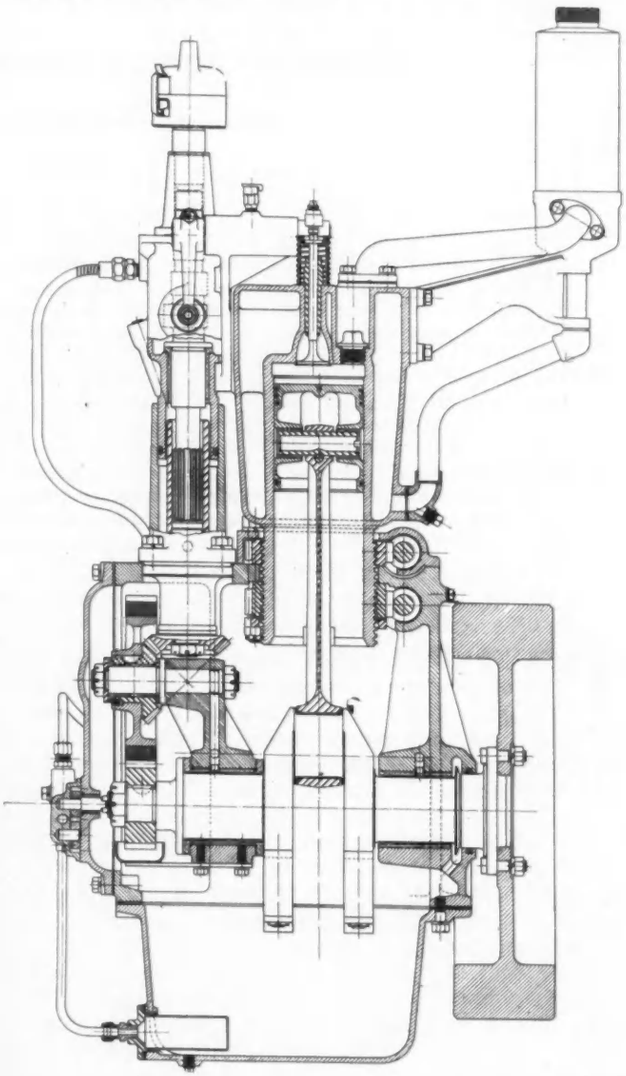


FIG. 2—CROSS-SECTION OF THE ENGINE SHOWN IN FIG. 1

Experimental Equipment Described

The detonation characteristics of these fuels were determined in the one-cylinder variable-compression engine shown in Fig. 1. This engine was designed and built in the research laboratories of our company, following a general design made by Henry M. Crane. The engine is of the valve-in-head type with a 3¼-in. bore

and a 4½-in. stroke. The compression ratio can be changed, even while the engine is running, by raising or lowering the entire cylinder-head and valve mechanism. This is accomplished by turning with a crank two collars which are threaded to the skirt of the cylinder. The collars are placed on either side of a supporting shoulder so that the cylinder-head can be clamped rigidly in place by turning down the upper collar separately against the shoulder, which is a part of the crankcase. This variable-compression feature of the engine is especially desirable for knock testing because it provides a convenient means of adjusting the engine to conditions favorable for testing any particular fuel whether its antiknock quality be high or low. The valves are actuated by rocker-arms through a vertical camshaft which is splined to allow for the up-and-down movement of the cylinder-head when the compression ratio is varied. Fig. 2 shows the general details of this construction.

The engine is connected to an electric dynamometer for absorbing the load and controlling the speed. An evaporative cooling-system that provides ample room for water circulation around the entire cylinder-head automatically maintains the jacket-water temperature at about 212 deg. fahr. The spark timing is observed by the flash in a small neon tube, attached to the flywheel, as it passes a stationary protractor which is insulated from the ground and connected to the high-tension wire leading to the spark-plug.

The carbureter was especially built for knock testing. It has a fixed jet and two float-bowls independently adjustable for height, so that the mixture ratio for each of the two fuels can be controlled as desired by adjusting the level of each float-bowl with respect to the common fuel-jet. A three-way cock inserted in the fuel line between the float-bowls and the jet makes it possible to change quickly from one fuel to another without interrupting the operation of the engine. The venturi tube of the carbureter is in a horizontal position and discharges the fuel mixture directly into the inlet port of the engine. No heat is supplied to the mixture before it enters the cylinder. The carbureter has no throttle, hence the engine is always operated with the same inlet opening. A muffler was attached to the intake of the carbureter during these experiments to reduce to the minimum the sucking noise during the intake stroke.

Method of Making Knock Measurements

Comparisons of the detonation characteristics of the fuels and fuel mixtures used were made on the basis of the compression ratio for borderline detonation or incipient knock. This critical compression-ratio is defined as that at which detonation becomes just audible under the following specified conditions of operation: full load; engine speed, 600 r.p.m.; jacket-water boiling, 212 deg. fahr.; mixture ratio for maximum power; and spark advance for maximum power.

This procedure is similar to that employed by H. R. Ricardo several years ago[4], the chief differences being that he chose 1500 r.p.m. as his working speed. We have used a low speed in this work for the following reasons:

[4] See Report of Empire Motor Fuels Committee (1923-1924), Institution of Automobile Engineers (London), vol. 18, part I, p. 77.

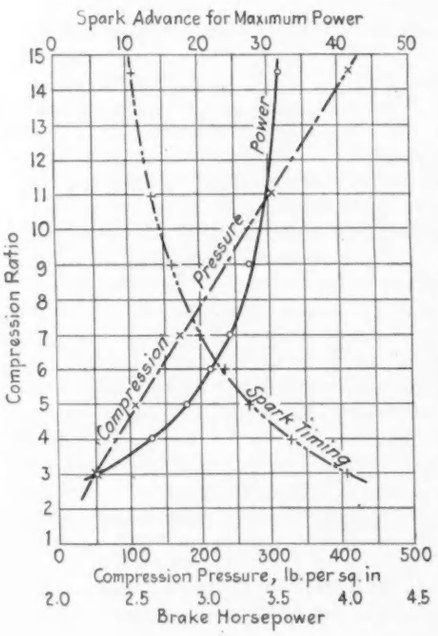


FIG. 3—SHOWING BRAKE-HORSEPOWER OUTPUT, SPARK TIMING FOR MAXIMUM POWER, AND COMPRESSION PRESSURE PLOTTED AGAINST COMPRESSION RATIO

These Curves Apply to This Engine Only When It Is Operated According to the Procedure Outlined

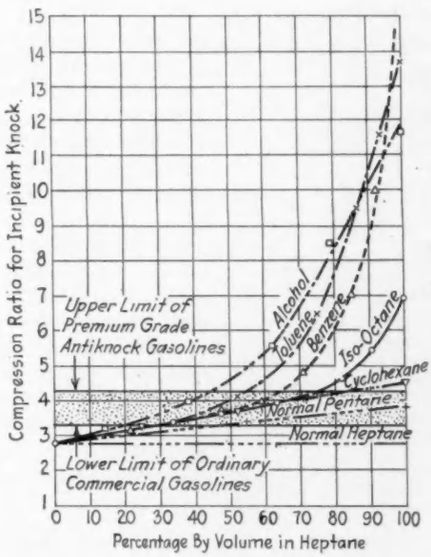


FIG. 4—GRAPHICAL REPRESENTATION OF DATA IN TABLE 2

Showing Relative Detonation Characteristics of Several Fuels in Admixture with Normal Heptane at Concentrations from Zero to 100 Per Cent by Volume. The Shaded Band Represents the Range of Compression Ratios within Which Most of the Gasolines That Are Being Marketed Today Begin To Knock

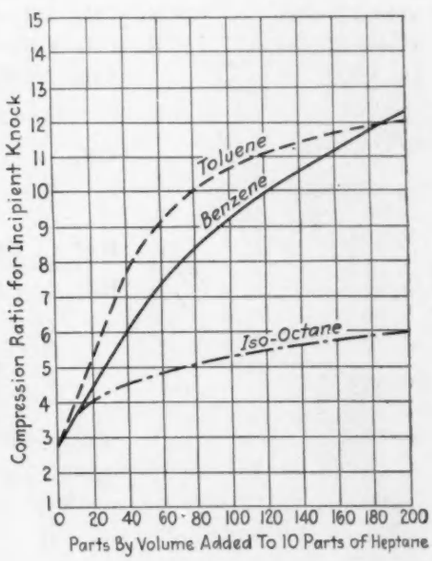

Compression Ratio for Incipient Knock
Toluene
Benzene
Iso-Octane
0 20 40 60 80 100 120 140 160 180 200
Parts By Volume Added To 10 Parts of Heptane

FIG. 5—COMPOSITION OF FUEL MIXTURES BASED UPON PARTS BY VOLUME ADDED TO 10 PARTS OF HEPTANE PLOTTED AGAINST COMPRESSION RATIO FOR INCIPIENT KNOCK

On This Basis the Composition of Benzene-Heptane Mixtures Have Nearly a Straight-Line Relationship to the Compression Ratio

(1) An engine runs more quietly at lower speeds and the accuracy of determinations made by ear is correspondingly greater.

(2) From the practical viewpoint, knocking in automobiles is most objectionable at low speeds and full load.

(3) At low speeds an engine requires less fuel, of which sometimes only a limited quantity is available.

(4) At the lower speeds the temperature within the combustion-chamber, especially of the spark-plug and exhaust valve, is lower, therefore more uniform operation of the engine can be expected.

(5) The tendency of any fuel to knock is greater at low speeds than at high speeds, hence it becomes possible to obtain knock measurements on some fuels which could not be made to knock at high speeds.

Experiments were made which indicate that the spark advance for maximum power at compression ratios close to the detonation point is not appreciably affected by the chemical composition of the fuel whether the latter be a hydrocarbon or an alcohol. For this reason the spark timing was adjusted for maximum power at each compression-ratio in conformity with a previously determined curve, such as that shown in Fig. 3. This figure shows also the gage compression-pressure and the brake horsepower of the engine at various compression-ratios extending from 3:1 up to 15:1 under the standard operating conditions.

The mixture ratio was adjusted in each case for maximum power as indicated on the beam of the dynamometer scale. This adjustment was much easier to make experimentally than that for maximum knock, although the two were identical as nearly as could be determined by ear.

The compression ratio was determined by measuring with a micrometer the distance between two fixed anvils, one fastened to the cylinder-head and the other mounted on the crankcase. The compression ratio corresponding to this distance was then obtained from a calibration curve previously prepared.

Fuels Available

The fuels on which detonation data are presented are listed, together with their structural formulas, densities, boiling-points, and sources, in Table 1. Some of these fuels have been proposed definitely as standard fuels. Dr. Graham Edgar proposed for this purpose the use of mixtures of normal heptane, a paraffin hydrocarbon of low antiknock quality, and iso-octane (2, 2, 4-trimethyl pentane), a hydrocarbon of high antiknock quality[5].

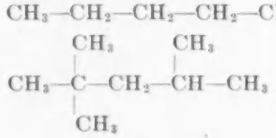
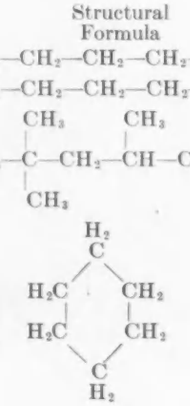
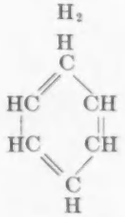
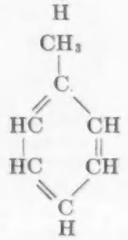
R. Stansfield and F. B. Thole have suggested a modification of Edgar's plan, consisting in the substitution of benzene for iso-octane[6]. Toluene with heptane has also been used by H. R. Ricardo and O. Thornycroft to produce reference fuels with a range of antiknock quality[7].

[5] See S.A.E. JOURNAL, February, 1927, p. 245.

[6] See *Journal of Industrial and Engineering Chemistry; Analytical*, vol. 1, p. 98 (1929).

[7] See Paper No. N6, Transactions of the Fuel Conference, World Power Conference (London), 1928, vol. 3, p. 662.

TABLE I—FUELS ON WHICH DATA ARE PRESENTED

Fuel	Structural Formula	Density at 20 Deg. Cent. (68 Deg. Fahr.)	Boiling-Point, Uncorrected	
			Deg. Cent.	Deg. Fahr.
Normal Pentane	$CH_3—CH_2—CH_2—CH_2—CH_3$	0.631	34.7– 41.0	94.5–105.8
Normal Heptane	$CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$	0.686	96.8– 99.4	206.6–211.0
Iso-Octane		0.691	97.6– 99.8	208.1–212.0
Cyclohexane		0.779	79.5– 81.0	175.5–178.0
Benzene		0.878	79.0– 79.0	174.5–174.5
Toluene		0.866	108.0–109.0	226.8–228.6
Ethyl Alcohol	$CH_3—CH_2OH$	0.789	78.1– 78.1	173.0–173.0

Tabulation and Discussion of Data Obtained

The results of the investigation herein reported are tabulated in Table 2 and are shown graphically in Fig. 4, in which is presented the relationship between the composition of each of the various mixtures, expressed as percentage by volume in normal heptane, and the compression ratio for incipient knock. In Fig. 4 the compression ratio for incipient knock is measured on the vertical axis and the percentage of admixture with normal heptane on the horizontal axis. The shaded band represents the range of compression ratios within which most of the automobile fuels that are being marketed today begin to knock. The upper limit of the band corresponds to the antiknock fuels and the lower limit to the regular automobile gasolines. Most regular automobile gasolines come well above this lower limit. A gasoline which was approximately equivalent in knock rating to the average of the Country, as found by the United States Bureau of Standards detonation survey of 1927 and reported upon by H. K. Cummings[*], began to knock at a compression ratio of 3.6:1, or almost midway between the limits of the shaded band.

The data show that normal heptane begins to knock at a compression ratio of 2.75:1. When a substance of higher antiknock quality is added to normal heptane in increasing proportions, the compression ratio can be increased without knock, along the curves of Fig. 4, until the compression ratio is reached at which the fuel of higher antiknock quality itself begins to knock.

It is important to note that the numerical values assigned to the compression ratios for incipient knock in this work apply only to this particular engine when it is operated under the conditions existing at the time the experiments were made. The characteristics of this engine are such that, in general, the limiting compression-ratios reported here are about one ratio below those corresponding to conventional automotive-engine experience.

The compression ratio for incipient knock could be determined, at the time the experiments were made, within 0.05 of a compression ratio. By this it is meant that detonation would be inaudible if the compression were lowered 0.05 of a ratio below that determined for incipient knock. This procedure constituted the experimental technique employed for establishing the compression ratio for incipient knock.

At compression ratios above 10:1 the manifestation of "roughness" made more difficult the distinct detection of the characteristic sound of detonation. This roughness, however, should not be confused with preignition, which is an altogether different phenomenon. Under the conditions of these tests preignition was never observed at a compression ratio below that at which knocking began. The effect of normal variations of atmospheric conditions upon the determinations was negligible, so far as was observed during the period of these tests.

Some Factors Influencing the Selection of Reference Fuels

The range of antiknock quality of the fuels to be rated is an important factor to be considered in the selection of the fuels which are to be the most suitable for use as standards of antiknock quality. Some gasolines are known which begin to knock at compression ratios as low as 3:1 in the engine used for these determinations; hence normal heptane, which has a limiting compression-ratio of 2.75:1, under the conditions of these tests, is the only one of the hydrocarbons included in this survey the limiting compression-ratio of which is low enough to form the base-line of the scale.

Selection of the most suitable substance for use to form the upper limit of the scale of antiknock quality is not so easy to make. Normal pentane is hardly suitable because its antiknock quality or limiting compression-ratio is below that of many of the gasolines currently sold. The extremely high volatility of normal pentane is also undesirable. Cyclohexane might be an excellent material to form the upper standard of antiknock quality if the range within which knock ratings are to be made were to be confined to that covered by present-day automobile-fuels.

Fig. 4 shows that a convenient straight-line relationship exists between the compression ratio for incipient knock and the composition of cyclohexane and heptane mixtures. This seems to be desirable from the viewpoint of a standard fuel of variable composition, because it would provide a uniform change in standard-fuel composition over all parts of the scale. Another feature of mixtures of cyclohexane and heptane that

TABLE 2—RESULTS OF THE INVESTIGATION
SEE FIG. 4 FOR GRAPHICAL ANALYSIS

Composition of Fuel, Percentage by Volume in Heptane		Compression Ratio for Incipient Knock
100.0	Normal Heptane	2.75
0.0	Normal Pentane	2.75
53.9		3.40
100.0		3.80
0.0	Iso-Octane	2.75
33.0		3.35
47.7		3.60
63.0		3.90
73.0		4.20
82.0		4.65
91.5		5.40
100.0		6.90
0.0	Benzene	2.75
20.9		3.15
47.7		3.65
59.0		3.95
71.0		4.80
85.0		7.05
92.3		10.00
100.0		above 15.00
0.0	Toluene	2.75
23.8		3.23
52.5		4.10
74.6		6.50
87.2		9.50
93.5		11.60
100.0		13.60
0.0	Cyclohexane	2.75
24.5		3.25
52.8		3.70
100.0		4.50
0.0	Absolute Ethyl Alcohol	2.75
14.6		3.20
37.7		3.97
61.6		5.60
78.8		8.50
100.0		11.60

[*] See S.A.E. JOURNAL, April, 1928, p. 448.

seems desirable is that an inaccuracy of 0.5 per cent in measuring out the respective volumes of cyclohexane and of heptane would not introduce a large error in the knock rating of the mixture. This comes about because of the narrow range in antiknock quality represented by the entire scale, and it would make it unnecessary to use extremely accurate measuring vessels in preparing mixtures of the two standard fuels, as is the case with some of the materials discussed later; but the adoption of cyclohexane as a standard would place an upper limit on the scale of antiknock quality that would be only slightly higher than that of some of the automobile fuels distributed today.

Iso-octane is one of the first compounds proposed for use as a standard fuel in mixtures with normal heptane, and it has been used to some extent. One of the points mentioned in favor of mixtures of iso-octane and normal heptane as standards of antiknock quality is that the common physical properties of these two hydrocarbons are almost identical, and thus the physical characteristics of the mixtures remain practically unchanged over the entire range of composition.

One possible disadvantage of iso-octane is that some fuels might be found that have a higher antiknock quality than iso-octane itself, which has a limiting compression-ratio of 6.9:1 under the conditions of this survey. However, it may be that for a time, as far as automobile practice is concerned, such fuels may be used for blending purposes only. In such cases the antiknock quality of the fuel, in admixture with the fuel with which it is to be blended, should be determined. The reason for this is that the knock rating of a pure substance cannot be taken as a direct indication of its effectiveness for improving antiknock quality in a blend. This is another point which is evident from the data presented in Fig. 4; for example, the antiknock quality of pure benzene is superior to that of iso-octane although, in blends with normal heptane up to 50 per cent, iso-octane is just as effective by volume as benzene for increasing the antiknock quality of the mixture.

Benzene and toluene are both quite high in respect to antiknock quality when used alone, the limiting compression-ratio for toluene under the conditions of these tests being 13.6:1, and that for benzene being more than 15.0:1. Both benzene and toluene have been used as reference fuels in making knock ratings. One of the apparent disadvantages of these substances for use in mixtures with normal heptane is the relatively large variation in antiknock quality that is brought about by a small change in the composition of the mixture on certain parts of the scale. Thus, at the point corresponding to the upper limit of the premium-grade gasolines referred to in Fig. 4, a variation of 0.5 per cent of benzene in heptane is equivalent to about 0.04 of a compression ratio or to about 0.2 cc. of tetraethyl lead per gal. This variation in concentration of tetraethyl lead is greater than the tolerance desirable in some knock ratings. Accordingly, great care is necessary in measuring out the components of these mixtures when they are to be used as standard fuels. It is also essential that the benzene used for this purpose be of a high degree of purity.

Another apparent disadvantage of mixtures of benzene or of toluene with normal heptane is the large variation in antiknock effect resulting from a given change in composition on different parts of the scale. For example, referring to Fig. 4, increasing the concentration of benzene in heptane from 30 to 40 per cent permits an increase of 0.2 of a compression ratio; whereas an increase in concentration of benzene from 80 to 90 per cent allows an increase of 2.8 compression ratios. So, over the latter range, a given change in concentration of benzene produces nearly 15 times as large an effect on antiknock quality as over the former range. This objectionable feature is overcome somewhat by plotting the scale of knock rating on the basis of the amount of benzene added to a constant volume of normal heptane, as shown in Fig. 5.

In Fig. 5, compression ratios for incipient knock are plotted on the vertical axis, as in Fig. 4, but along the horizontal axis the concentrations of benzene, of toluene, and of iso-octane in heptane are plotted on the basis of number of parts by volume of these substances added to 10 parts by volume of normal heptane. This means that 10 on the horizontal scale of Fig. 5 corresponds to the 50-per cent point in Fig. 4, and that 30 in Fig. 5 corresponds to the 75-per cent point in Fig. 4. The result is that, in Fig. 5, benzene and heptane proportions have a straight-line relationship to compression ratio up to 40 parts of benzene in 10 parts of heptane, which corresponds to 80 per cent of benzene in heptane, or to a limiting compression-ratio of 6.0 : 1 under the conditions of this work. A similar relationship exists in the case of mixtures of toluene in heptane. Iso-octane does not lend itself to this method of plotting to any advantage.

This latter method of constructing a scale of knock rating has been presented here to illustrate that, not only is there a choice as to the most suitable compound to serve as a standard fuel, which definite selection it is not a function of this paper to make, but that the method of expressing results or of establishing the scale of antiknock quality in the best and most useful form is also a matter that needs consideration.

Sheet Steel and the All-Steel Body

By GEORGE L. KELLEY[1]

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND DRAWINGS

THE REQUIREMENTS as to surface and drawing qualities which must now be met by flat steel stock would have been impossible a few years ago. Within this time have come improvements in all of these products. Strip steel is now made on continuous mills which operate at a remarkably high speed. The process from the billet to the finished cold-rolled strip, including the intermediate annealing and pickling, is almost continuous and may be regarded as a straight-line process, at least in some plants. Four high mills have made possible wider strip in a very close gage-range, and improvement in annealing processes has bettered the drawing qualities of the product. Roll breaks and stretcher strains need no longer cause the stamping plant added cost in finishing.

Sheet steel is now available in widths up to 72 in. and with excellent control of gage. Normalizing as a process of heat-treatment is not new but its use, instead of being occasional, is now becoming general. In former days the sheets so made were tough, but they were stiff and the surface was not of good quality. Now the stiffness need be only a little greater than that of the box-annealed sheet and the sheets exhibit greater ductility and toughness, together with a surface quite as good.

It may be of interest to comment on the laboratory investigation of sheet steel. A grade of steel is ordered which the purchaser believes will best make the stamping. The specification relates only to process of manufacture, surface and drawing qualities. Experience has indicated that the degree of elongation is the most significant property. Accordingly, tests are made on a tensile specimen in which the gage length is 8 in. and the width ¾ in. The most difficult draws require that the elongation be greater than 25 per cent in both longitudinal and transverse directions. Even under these conditions it is not possible to substitute at will strip, normalized sheet and box-annealed sheet. These require different pressure adjustments and in the case of sharp formations may require different radii. The weaker box-annealed sheet must be allowed a better opportunity to slip during the formation.

Rockwell hardness-tests probably will be useful in testing strip steel but of doubtful value on the other types. Cup tests have more significance as applied to strip and normalized sheet than when used with box-annealed sheet, but their value is doubtful in any case. The microscope is useful as a means for supplying related information. X-ray diffraction photographs have been suggested and may prove useful from a research point of view even if they are not directly helpful in a control laboratory. Flat steel stock, as determined by the melting practice in which it has its origin, is a heterogeneous metal and tests of it are better made on large samples.

[1] M.S.A.E.—Metallurgist, Edward G. Budd Mfg. Co., Philadelphia and Detroit.

The writer and his colleagues believe that studies of conditions affecting grain size may help to produce sheet metals of better and more uniform drawing qualities. Such studies should be supplemented by further work on plastic flow and elastic recovery in this class of materials.

All-Steel Automobile Bodies

The first automobile bodies were built according to designs suggested by experience in building horse-drawn vehicles. The earlier locomotives show their relation to the preceding devices used for material transportation. Both have undergone evolution and improvement with time. New materials, new engineering and a new artistic treatment have made this possible.

Herbert Spencer said, "that evolution is the change of the homogeneous to the heterogeneous." But theories

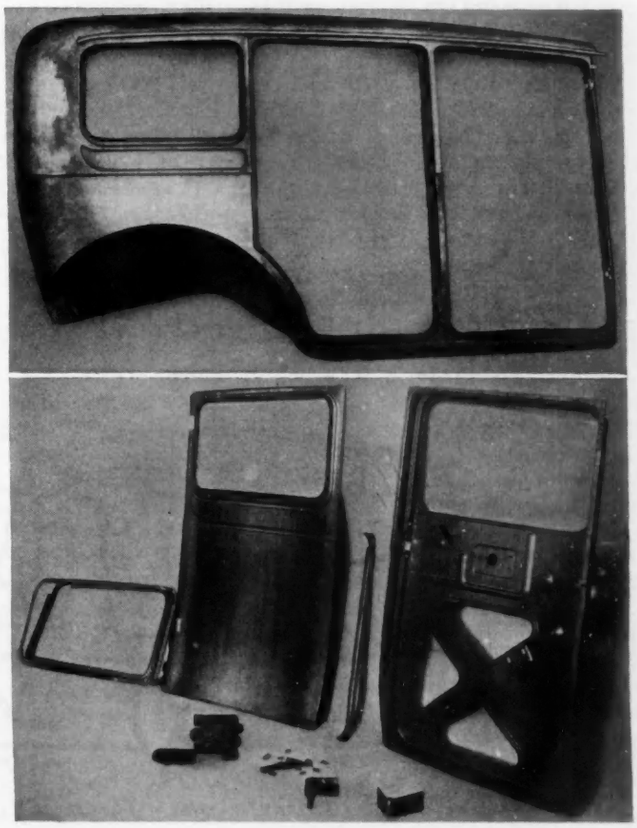


FIG. 1—SIDE-PANEL AND DOOR PANELS OF ALL-STEEL BODY

Door and Window Openings Are Formed Complete in the Side-Panel Stamping, Which Includes Roof Side-Panel and Body Sill. The Door Consists Essentially of an Inner and an Outer Panel and a Glass Run-Channel. Each Is Clinched and Welded to the Other Door Parts

of evolution have undergone marked changes since his day, and the evolution of the automobile body has been so different from that predicted by his theory that he would in the interest of logic, be forced to regard it as regressive. The change has been from the complex to the simple. To us, however, this development represents great advances. We have in the automobile bodies of today a striking comeliness of contour, strength and endurance in service, and unequaled riding-comfort. Such improvements as we have we must attribute to our artists and engineers and to the great improvement in the materials available for use in bodies. The lacquer finishes now in use permit of great variety and beauty in selection of colors and they are durable. The selection of trim materials is now wide and permits the use of attractive linings in cars sold at even the lowest prices. All bodies, too, are quieter and stronger than in former times.

Automobile bodies now in use fall into two general types. One of these is made up chiefly of a wood frame to which metal stampings are attached and which cover it completely, while the other is made almost entirely of steel with, at the most, only a bit of wood here and there, used perhaps for the attachment of upholstery. These two types are commonly designated as composite and all-steel bodies. In the former the strength depends largely upon the wooden structure underlying the shell. In the all-steel body the shell itself is a chief strength member, with only occasional other steel supporting members distributed at critical points. This use of the shell, as a strength member, is unique in body construction from the engineering standpoint. From this fact many advantages arise.

The all-steel automobile body, like other parts of the automobile, has had a gradual development. The earlier types were built up of 450 to 500 separate parts. These were first assembled into small units and these in turn into larger units before assembling into a complete body. The assembly of such a body by riveting and welding required the use of numerous accurate assembly-jigs to assure that good fits might result. The construction offered many opportunities for movement among parts, which would be attended by squeaks and rattles, and the open seams made a satisfactory paint job difficult to obtain.

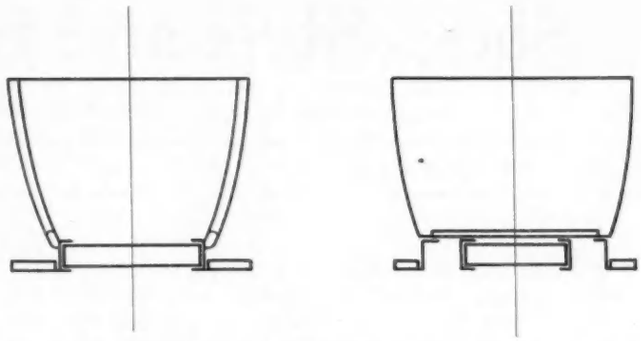


FIG. 3—DIAGRAMS OF MOUNTING OF ALL-STEEL AND CONVENTIONAL COMPOSITE BODIES

At the Left the New Type of Body Is Mounted Directly on a Wide Chassis-Frame, Providing Great Stability. The Conventional Body at the Right Is Mounted on a Narrow Chassis-Frame, with a Sill and Splasher

Shell Made of Four Principal Stampings

In the new type of body, exclusive of the doors, only four principal stampings are used: two side-panels, a rear panel and a cowl. The two side-panels are flash-welded to the rear panel, producing strong invisible joints, and the cowl is fastened to the other combination stamping by welding and clinching. Thus the body is virtually one piece of metal. Reinforcing members are introduced at various places, notably in the posts, by clinching and spot-welding. The metal at the edges of window openings is clinched inward about the glass run-frames.

Note in Fig. 1 that the door and window openings are formed complete in the original stamping, which also includes the roof side-panel and the body sill. The door parts shown below in Fig. 1 indicate that the same simple type of construction is used for them also. A door made by this method consists essentially of an inner and an outer panel and glass run-channel. Each is firmly and immovably fastened to the other by clinching and welding. Such doors entirely lack the unpleasant sound formerly produced when closing a metal door.

Fig. 2 shows a section through one side of the front and rear doors and the *B-C* post. This shows how the metal construction is employed to provide for glass run-parts and for the attachment of upholstery. The drawing illustrates the method of clinching the edges of outer stampings to the inner ones. This is of great assistance in obtaining good

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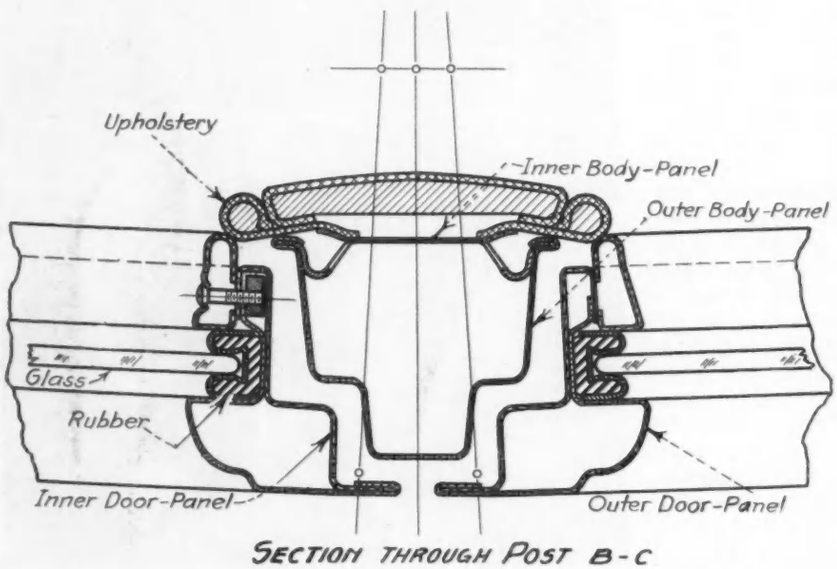


FIG. 2—CROSS-SECTION THROUGH ONE SIDE OF FRONT AND REAR DOORS AND THE DOOR POST

Note Method of Clinching Edges of Outer Panels over Those of Inner Panels, Which Avoids Exposed Raw Edges, Resulting in Good Painting Conditions and Protection against Rust. As There Are No Sharp Corners, the Body Is Easy To Clean. Relative Movement of the Parts Is almost Impossible, Hence the Body Is Quiet

The Convertible Body—Its Evolution and Possible Future

By L. C. Hill[1]

Detroit Section Body Division Paper

Illustrated with Photographs

THE present world-wide vogue for the outdoor life, vigorous health and sun tan is assumed to presage a demand by motorists for a vehicle that will remove them from the shut-in class. Moreover, large portions of the United States enjoy climatic and meteorological conditions that make riding in a car with the top folded back comfortable and enjoyable. Even in the northern States a large percentage of the days in the year are favorable to open-car riding. Hence, increasing popularity of the convertible body may be expected.

Reasons are given for the passing into oblivion of the early open cars and of winter tops and the predominance of the closed sedan. All the disadvantages of the open car are said to have been overcome by the simple expedient of mounting disappearing sash glasses in the car doors in combination with a folding roof or top that collapses with reasonable ease and stows compactly. Attempts to build such a body by retaining bows and other features of the open-car or phaeton top have rarely proved satisfactory. With good engineering skill and manufacturing precision, however, a convertible body can be built that will give the owner years of satisfactory service. How this is accomplished by Dietrich, Inc., is described and illustrated. Important features are extra-heavy pillars below the belt line, to give substantial support for the doors and the hinged roof-rails; unusually heavy hardware to give rigidity; folding roof-rails or ribs; use of sponge-rubber blocks to prevent metal-to-metal contact; use of eccentric fittings in place of thumb-nuts or knurled screws; and other special devices and means adopted to avoid rattles, give good visibility and present a pleasing appearance.

Companies contemplating building convertible bodies are cautioned regarding the importance of extreme accuracy in producing and assembling the parts and in mounting the body on the chassis. And a plea is made to suppliers of top material to develop a nonshrinkable, impervious, easily cleaned coated or impregnated fabric.

Convertible bodies are not now on a large-production basis and are not within reach of persons of small means, but the day may come when engineering skill and increased demand will make them available on moderate-priced cars. They cannot be built, however, on assembly lines by present quick-work methods.

Discussion of the paper is largely on the subject of a suitable top material, the possibility of application of the convertible body to medium-priced cars, and the importance of the owners giving more attention to keeping the chassis in condition.

JUDGING from the scantiness of some of the 1929 wearing apparel, this might be called the back-to-nature year. Vacationists and week-enders have staged the keenest competition in history to attain the deepest coat of sun tan. Those not fortunate enough to enjoy exposure to the sunlight have been served by our scientists through the development of ultra-violet-ray lamps which purport to do in ten minutes what the sun cannot accomplish in a week-end. This craze for closer contact with nature's invigorator may or may not be a fad. With the entire Nation leaning more and more to outdoor athletics, it seems that the movement is permanent rather than temporary. Does this not indicate a possibility that the desire to gain more of the benefits of exposure to nature may result in the motorist demanding a vehicle which removes him from the shut-in class?

Recognition must be given to the fact that there are heavily populated areas in our Country where the weather permits the folding of tops for a large part of the time throughout the entire year. Florida and the other Gulf States are typical. Then there is the lower Pacific Coast region where, if we are to believe the Californians, it seldom if ever rains. Even in Detroit, conditions may not be as bad as we sometimes think them. A careful check of the Government weather reports reveals that during the months from May to September, inclusive, out of 153 days we had 118 days in Detroit without rainfall. The weather man goes even more carefully into detail and informs us that during this period we had a total of 1442 hr. of sunshine out of a possible 2169 sunshine hours. This does not necessarily mean that it was raining during the remaining hours when the sun did not shine, as undoubtedly many of these hours could be classified as cloudy but without any rainfall. Thus it would have been possible to enjoy a major part of the summer months in Detroit without being cooped up in a closed car. Greater appreciation of this condition may result in increasing popularity of the convertible body.

The Europeans have sensed the demand for a convertible vehicle but have started off on a different track from ourselves. They have developed bodies which are essentially sedans with sliding or stowable middle-roof sections. These were largely intended for sightseeing in the country, especially in the mountainous regions. However, they unquestionably appeal to prospective owners who are as much interested in the benefits of exposure to the natural elements as in the passing scenery. Incidentally, there are millions of square miles of beautiful American scenery which can never be seen to its full glory by peeping out from under the quarters and through the windows of a sedan body.

These European developments seem to be half-way

[1] M.S.A.E.—Vice-president and general manager Dietrich, Inc., Detroit.

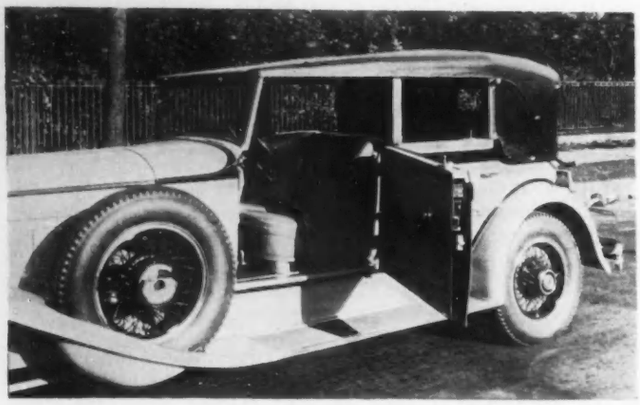


FIG. 1—CONVERTIBLE SEDAN BODY MOUNTED ON A PACKARD MODEL-745 CHASSIS

measures, for, after all, the car remains in fact almost a closed car, even with the roof open. Such a car can hardly be compared with our modern American convertible sedan, which is completely collapsible above the belt.

Why Open Cars Became Obsolete

An analysis of the reasons for the passing of the open touring car and phaeton may be of interest, to see what bearing these have on the future for convertible bodies. Open cars predominated in the early days of the industry because closed cars were too expensive. Mass production gradually enabled our manufacturers to lower the price of the sedan until it very nearly approached that of the touring car. Still there were those who could not afford the sedan and these people demanded some measure of closed-car weather protection with their open cars. This brought the day of the makeshift winter top and all sorts of specially designed folding and sliding curtains. These were far from satisfactory because they were a makeshift and particularly because the public began to sense the importance of appearance. The motorist soon learned that the winter tops cost more than the conventional top, were but little improvement over the old flexible curtains, were decidedly unattractive in appearance and, in most cases, destroyed the folding feature of the open-car top. Thus the winter top died a natural death.

Efforts were made to improve the flexible type of curtain by adding door-carriers and various means of stiffening. However, the old ill-fitting curtain with its perishable celluloid lights remained. Even when fitted with the most extreme care, these curtains failed to keep out the elements in wintry weather. The stiffened curtains were extremely difficult to stow satisfactorily, and it was no little task to place and adjust them in case of a shower. If they were all placed properly, the complete absence of any means of ventilation through the windows meant no little discomfort to the occupants of the car. Without question, the greatest prejudice against the open car, as we have known it during the last 10 years, has been due to the old-fashioned flapping curtain with celluloid lights. All its disadvantages are overcome by the simple expedient of mounting disappearing sash glasses in the doors in combination with a folding roof or top that collapses with reasonable ease and stows compactly.

Convertible-Body Mass Production a Possibility

Some attempts have been made to build convertible bodies by using sash glasses in the doors in combination with a top which is largely a heritage from the open-car top. This part-way step is seldom if ever satisfactory. The top must be designed so that the roof rails and pillars, against which the door glasses seal when closed, are sufficiently rigid and in alignment to prevent leakage of air or water. This has led to discarding our old-fashioned top bows and sockets, replacing them with folding side roof-rails and falling main pillars. With good engineering skill and manufacturing precision, it is possible to build a convertible body of this modern type which will give its owner satisfactory service for many years. It is not being done as yet on a large-production basis nor at a cost which fits the smaller purses, but one cannot help feeling that his day, too, may come, as it did in the case of the sedan. Each year at the custom-body salons convertible bodies are seen in increasing numbers. As this demand increases, development will keep pace, and one hesitates to predict what engineering accomplishment will result. Increased use of the convertible body is resulting in intensive study of those defects which had heretofore been regarded as inherent. Some of these problems have been and others are being solved. Our own organization is doing considerable engineering development work along this line, and we have no doubt that our competitors are doing likewise.

While this paper is intended primarily as a discussion of the future for the collapsible top, it does not seem impertinent to include a description of the present state of the art as evidenced by our own construction. It does not represent the result of one or two years' experimentation, but has been in the formative state for at least a decade.

Dietrich Convertible-Body Construction

Below the belt the Dietrich form of convertible body is not particularly different from that of a sedan. The belt-line height is determined, of course, by the necessity of having the glasses completely disappear when lowered. The glasses are all mounted in chromium-plated metal sashes to provide rigid support for the glass itself when in the raised position. The underbody is typical of sedan construction except that unusually heavy pillar-braces tie the hinge and lock pillars to the sills. The center pillar, which in many cases carries the hinge support for both front and rear doors, is braced with extremely heavy irons. In some instances we have made this pillar a casting, more recently utilizing heat-treated duralumin for this purpose. The door-hinges, locks and other hardware are especially heavy to provide for the greater strains and movements which occur in bodies having no solid roof to contribute to their rigidity.

It is above the belt that most of the advancement has been made in the construction of convertible bodies. The Dietrich type of convertible top is really an assembly of adequately heavy roof-rails or ribs, which are hinged together instead of being screwed and glued. The roof rails are not top bows of the usual semi-flexible type, but are heavy and hinged so as to fold down in sections. The success of a convertible top of this type depends largely upon the perfection of this hinge work.

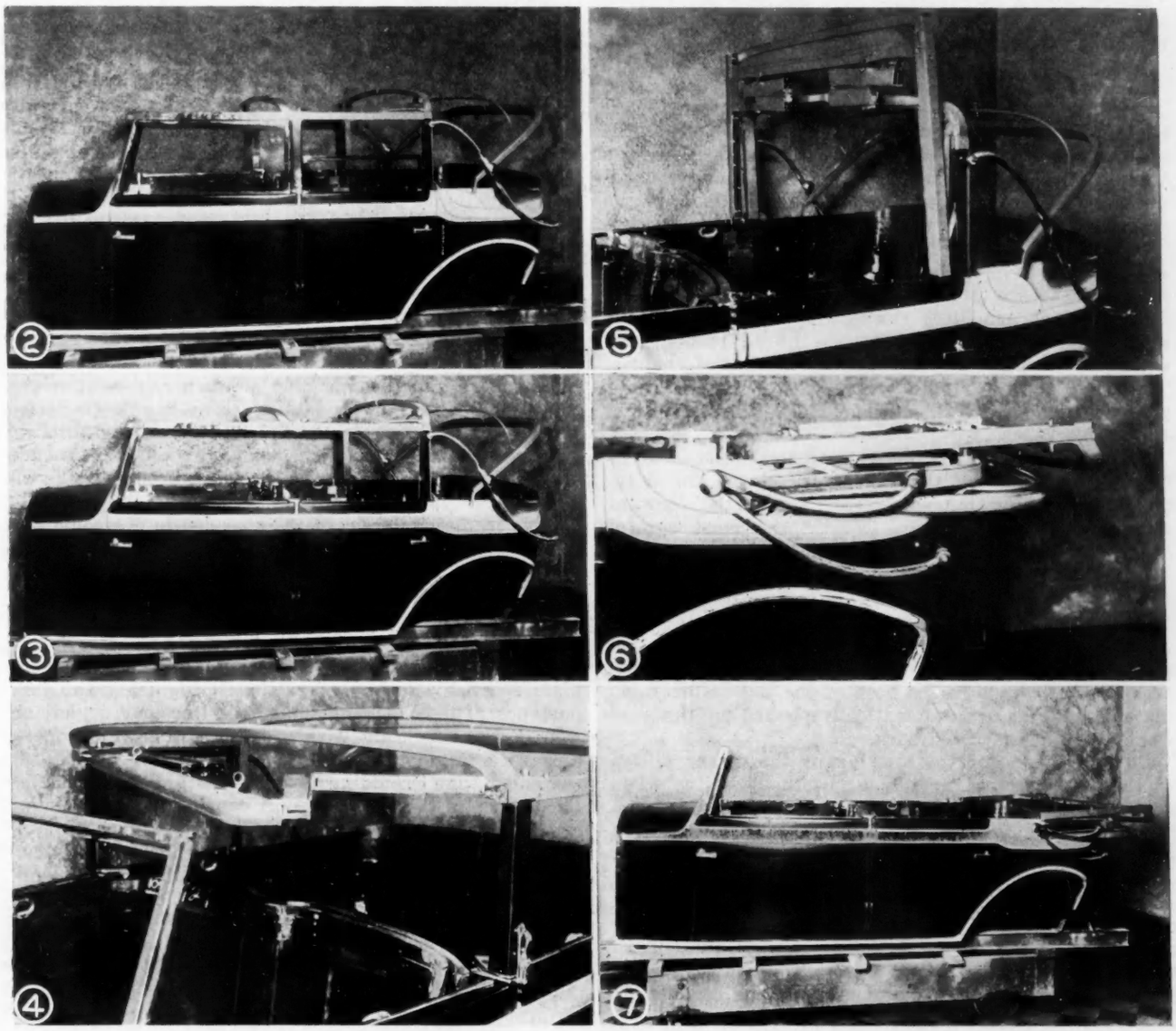
The tie across the body at the front-seat-back rail helps greatly to strengthen it. We cannot use the construction that prevails in sedan bodies in which the entire adjustable front seat moves. Instead, we have a stationary rail extending across the body, and the adjustable seat is provided with a bellows construction in the trimming to allow the seat to move fore and aft.

Sponge-Rubber Blocks Prevent Rattles

Not only must the 16 working units of the top-bow hinges be designed to assure compact stowage, but they must be assembled with custom-built accuracy so that they can move freely and still avoid annoying rattles. In the Dietrich top, metal contact between the several units is completely eliminated by the introduction of sponge-rubber blocks. The top may be said to float in this yieldable material so that, while the car is in use and the top is being subjected to severe torsional strain, its units may yield with the motion of the body. Two of these rubber blocks are used to support the top mechanism when it is folded, plenty of room being allowed for the deck material when in the stowed position.

One characteristic of the properly designed convertible body is that there is a considerable drop in the belt rail around the rear quarters and back panel so that the top stows compactly below the eye line and the passengers' shoulder line.

The accompanying illustrations indicate the elements of a Dietrich convertible-sedan top. Fig. 1 shows a typical Dietrich convertible five-passenger sedan body



DIETRICH CONVERTIBLE SEDAN BODY, UNTRIMMED, SHOWING SUCCESSIVE STAGES OF FOLDING

Fig. 2—Roof Assembly Exposed, Showing Substantial Sections of Roof Rails and Bows

Fig. 3—Center Pillars Folded Down Out of Sight, Preparatory To Folding the Top

Fig. 4—Windshield Header-Bar and Hinged Roof-Rails Folded Back toward No. 2 Roof-Bow

Fig. 5—Rear Side-Roof-Rail Collapsed against Main Top-Bow, Carrying Front Roof-Rail and Windshield Header-Bar with It

Fig. 6—Entire Top Structure Fully Collapsed

Fig. 7—Appearance of the Body as an Open Car Minus the Top Covering

mounted on a Packard Model-745 chassis. Fig. 2 shows a similar body, untrimmed, with the roof assembly exposed. Note the substantial sections of the roof rails and bows. In Fig. 3 the center pillars are folded down out of sight. This is the first move preparatory to folding the top itself. It is also possible to drive the car in this condition.

The second operation, by which the windshield header-bar and hinged roof-rails are collapsed to the rear in their position beneath the No. 2 roof-bow, is illustrated in Fig. 4. In Fig. 5 the rear side roof-rail has been collapsed against the main top-bow, carrying with it the collapsed front roof-rail and the windshield header-bar. These collapsed units are now ready to be rotated backward as soon as the laudau joint is broken. Figs. 6 and 7 show the entire top mechanism fully collapsed and the appearance of the body as an open car minus the top covering.

Minor Details of Major Importance

Attention is called to our use of what we term "over-center" or eccentric fittings. In no case do we use the old-fashioned knurled screws or thumb-nuts. The continual tightening of such screw fittings always produces wear and sometimes strips the thread of the screw, with the result that rattles are sure to develop. The eccentric or over-center fittings, on the contrary, are designed to provide a constant take-up. Their wearing surfaces are greater and, because of the take-up feature which usually works against the pressure of a rubber unit, these fittings require no adjustment and will serve satisfactorily throughout the life of the car. They keep the top rigidly in position at all times and yet they do not hinder its floating action in the sponge-rubber blocks.

The thought that has been given to details in these tops is indicated by the ingenious scheme for automatically opening the snap fasteners at the forward end of the rear quarter. Despite the most careful efforts to instruct owners to open these fasteners before collapsing the top, it was found that this would not be done. Sooner or later this failure to loosen the fasteners would invariably result in tearing the rear quarter badly. In the Dietrich patented construction small inclined cam-surfaces on the folding-pillar hinge press against studs in the base of the top fasteners so that the buttons are automatically pushed off the stud when the pillar is tilted back.

Our provision for the stowing of the center pillars so that these are completely below the belt line when not in use is for the purpose of providing all the benefits of an open car. For this same reason we have been advocates of the clear-vision type of windshield post, which is cast smaller in section than the inter-pupillary distance between the eyes. Not only does this afford clear visibility when the top is up, but it also provides a post the design of which follows closely that of an open-car windshield. It certainly looks much better than the stump 4 x 4-in. posts of the usual convertible body.

Convertible sedans of an earlier day always included some units such as the center pillars which had to be removed and stowed under seats or in some other inconvenient compartment. An effort has been made in the Dietrich design to eliminate all such loose pieces. For example, the center-pillar has a substantial hinge at the base where it joins the belt rail. Thus the pillars are tilted in and downward into the recess where the back of the front seat joins the body side. In the case of partition bodies, this pillar also has hinged to it the small side-glasses which reach inward to join the regulator-controlled partition glass and are carried with the pillar into the stowed position. There are no loose parts to be lost or that require displacing the passengers so that the top can be either raised or lowered.

In all frankness we must say that the convertible top is not intended to be a one-man top. This does not mean that it is not possible for one man to lower it without assistance, but the folding is much more readily accomplished with less likelihood of damage to the top if it is performed by two persons. To make the structure light enough so that one person could handle it easily would result in its being so frail that it would have excessive movement when the car is in motion.

Provisions for Avoidance of Rattles

Rattles have been the principal bugbear of convertible bodies. We believe that most of the cause for this criticism has been eliminated in the modern custom-built convertible body. In all instances of complaints received regarding bodies and tops that rattle badly, it has been found possible for a person who understood the top and body mechanism to service the bodies in only a few minutes. The principal difficulty has resulted from the general ignorance of body construction, not only of convertible bodies but of all bodies, which persists among service-station employes. I have explained how the Dietrich top floats in sponge-rubber components. We all know that rubber wears and deteriorates, but the replacing of worn rubber bumpers is very simple. Service stations that handle convertible bodies are being instructed to do this work intelligently, enabling an owner to have the adjustments made at nominal cost and with only a limited tie-up of the car.

It is true that development is needed to overcome the tendency for door-glass moldings to wear and work loose so that play develops around the glass sashes. If the glass frame-channels are fitted too tightly, excessive friction results and the car owner complains that the window regulators work with too much effort. If the friction is reduced, the owner complains that the door glasses are too loose and rattle. Recognizing the importance of development along this line, our organization is experimenting with a construction which operates with minimum effort on the regulator handle, at the same time providing absolutely rigid mounting of the frames in their channels. A door carrying this new mechanism has been placed in a testing machine and the glass frame elevated and lowered 28,000 times. The same door has been slammed 10,000 times. In no case has glass breakage resulted or sufficient wear developed in the supporting superstructure to cause the slightest tendency to rattle. We are not yet in a position to describe this mechanism, because we still feel that it should be tested most strenuously before supplanting the present-day construction. When our tests are completed, we shall incorporate the features of this design in our standard construction and release a description of the arrangement for publication.

Let us give a few words of caution to companies contemplating the manufacture of convertible sedan bodies. We cannot urge too strongly the importance of building the entire top mechanism in accurate jigs, so

that all locating points are checked carefully with relation to one another to permit compact stowage and easy folding. The top hardware must be machined with precision; it cannot be fitted in the haphazard way often followed on mass-production body lines, a condition which has contributed to many convertible-body failures in the past.

The body, having been built on rigid skids, deserves the most careful mounting to preserve the accurate relationship of the folding mechanism. If shimming is not done with great care when the body is mounted, it is possible to throw the top mechanism sufficiently out of line so that it will operate unsatisfactorily and to set up strains on the top that will eventually produce excessive wear. We cannot caution users of convertible bodies too strongly on the necessity of accurate shimming when the bodies are mounted on the frame.

We make one plea to the suppliers of material for convertible bodies. A top material that is wholly satisfactory for this use has not been developed. The average Burbank material, if stretched sufficiently taut to present a trim appearance, shrinks excessively when exposed to wet weather so that it gives the top a raw-boned appearance and frequently pulls out the fasteners. Furthermore, the public demands almost exclusively the lighter-colored top materials on convertible bodies. These become dirty and discolored long before the top has fulfilled the anticipated service required of it. We ask our friends in the textile field to devote intensive research toward the development of a fabric, either coated or uncoated, which will be better adapted to service on convertible tops.

This paper seems to be a statement of the present condition and future possibilities of the convertible-sedan type of body. It would be foolish to admit that such a body cannot be made practical, and in most instances when we hear criticisms of this body type we trace them to experience with bodies built several years ago, with no allowance made for the steps in advance recently taken. There will always be a place for the convertible body, and in our opinion its future looks more promising than ever.

THE DISCUSSION

CHAIRMAN H. R. CRECELIUS[2]:—One thing I noticed that Mr. Hill did not dwell on is how nicely the body folds. The usual convertible body, when folded down, projects considerably over the rear, but the peculiar construction of the forward part of the superstructure of the Dietrich body makes it possible to fold the top very compactly.

A. F. DENHAM[3]:—I should like to ask Mr. Hill what the situation is with regard to leakage of snow and rain between the windshield and the header-bar on this new job.

L. C. HILL:—The body has a sponge-rubber seal at that place. We have driven these new bodies many thousand miles, and the sifting of snow through the windshield is not a serious problem. In a convertible type of body the glass frames cannot always be made to fit absolutely tight with strong pressure against the pillars, as do the doors in a sedan body; but I will say that the leakage is negligible.

Better Top Material Needed

QUESTION:—Do you think it is feasible to use a coated material on a folding top?

MR. HILL:—Not any of the coated materials I have seen. The reason I spoke of a coated material is that I thought it might start someone thinking about a semi-coated material that could be cleaned; a material, let us say, with some preparation impregnated into the pores of the fabric, so that dirt could not lodge there so permanently. The dust not only collects on the top, but rain and snow finally soak this dirt into the top material and, no matter how one tries to clean the top, this dirt cannot be got out. If the textile men would set to work they might develop something like the raincoat materials they are producing now that will stand cleaning, and have some kind of coating that will prevent the permeation of the dust into the material.

QUESTION:—Do you release the top material from the bows when the top is folded?

MR. HILL:—No, because it is not rigidly attached to the bows anyway.

A MEMBER:—If you used a coated material you might be able to roll it in such a way that it would not crack.

MR. HILL:—That would be difficult.

An Interesting Field for Research

QUESTION:—Mr. Hill, have you taken up the question of top material with the manufacturers very seriously?

MR. HILL:—Yes; as long as the custom-body business can utilize only a relatively few thousand yards, the top-material companies are not going to exert themselves to meet the problem; they are too busy building the millions of yards of deck material used on the stationary-top types of body.

We simply suggested the idea as a very interesting field for research. They never gave us a really satisfactory material for our old open-car folding tops, and still are not doing so. They give us one that looks attractive when the top is up, but if it is folded many times it is certain to crack, or it bakes-out in the sunlight and becomes so brittle that the top cannot be folded. That is really quite a problem for us and unfortunately one that we cannot solve ourselves.

A MEMBER:—I have taken this matter up with the mills and with their representative here in Detroit, and after a month or five weeks I have not been able to get a definite statement except that, whereas at first they said the shrinkage could be reduced to an absolute minimum, they told me last week that there was no end to the shrinkage of cotton material, especially in the weight we use for sport-top materials.

MR. HILL:—The fact that led me to bring up the subject is that extremely interesting developments have been made in nitrocellulose materials, even to the extent of weaving materials from nitrocellulose. I thought that perhaps, if some chemist happened to stumble across this, he might decide to sneak over in the corner of the laboratory and do a little work for us.

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[2] M.S.A.E.—Body engineer, Lincoln division, Ford Motors Co., Detroit.

[3] Field editor, *Automotive Industries*, Detroit.

Impervious, Nonshrinking Material Wanted

A MEMBER:—The minimum we have been able to get in actual figures for shrinkage on top material is 3 per cent for width and 1 to 1½ per cent for length. Multiply that by virtually 9 ft. from the top of the body on one side to the top on the other side over the top on an open car and you can see what 3 per cent makes and the amount of shrinkage a body maker is supposed to take care of in his top.

CHAIRMAN CRECELIUS:—The question of top material is very important. I have not seen any material made yet that is sun-proof and that does not fade very readily. I have my doubts about the coated material that Mr. Hill has in mind. These tops fold very nicely in the factory, with experienced hands, but when they are out in the owner's hands, it is quite different.

MR. HILL:—The sort of material I have in mind is not the old type of coated materials but a Burbank that is impregnated, treated with some type of material that will keep the dirt from actually getting into the pores of the material. It need not be a grained material but just treated with something to weatherproof it satisfactorily, keep the dirt out and reduce the shrinkage. If the fabric is impregnated with the right kind of material, the moisture will not get into it and we shall not have the great shrinkage and contraction.

CHAIRMAN CRECELIUS:—There is another point; it is the appearance of the top. If during a period of dry weather the top is kept down for a number of weeks, I have found by experience that any material in the fabric takes a permanent set, so that when the top is put up again its good appearance is ruined. Good materials can be manufactured and are on the market, but unfortunately they are very expensive. I have seen samples of them and tested them, but the question arises, will the purchasing department approve an order for it? The question of volume enters into the matter of price.

MR. HILL:—Usually our prospective customers are wealthy and do not worry about price, but they would like to have a material that will stand up.

QUESTION:—Do you think this type of body will ever be popular on a moderately priced chassis?

MR. HILL:—How do we know? One of the greatest mistakes all of us have made in the past is that we have thought we were working for some particular company. We are working for the public, and if the public should demand a convertible type of body, we are going to build it on any kind of chassis. I do not think that day is near at present and do not want to say that next summer we shall see convertible bodies on low-priced chassis, because I know from our own problems and the great amount of precision that is necessary to make such tops work satisfactorily that they certainly are not going to be built on the customary production-line where the parts are put together hurriedly. That certainly cannot be done with a convertible body, which is one of the main reasons that so far it has stayed in the custom-body field.

Top Troubles Due to Chassis Neglect

CHAIRMAN CRECELIUS:—I think that the purchasers of these convertible cars should be instructed to have them adjusted more frequently. As Mr. Hill has pointed out, many of the ills are not really the fault of the body but are due to chassis conditions. Settling of the frame and weaving have much to do with the body troubles, and if the users will give the chassis more thought instead of condemning the body when there is a little defect perhaps it will be possible for the cheaper cars to use them.

MR. HILL:—We have sent men out into the field to repair convertible bodies in cases where the purchaser has thrown up his hands and said the body was absolutely impossible to repair, yet in one hour's time a man who knew what he was doing has fixed that body so that the owner is highly pleased. This shows that the troubles are not serious and that the body is simple to fix if one knows how. We are instructing those service stations where our jobs are handled on how this work can be done easily and satisfactorily.

QUESTION:—What protection is used for the top when it is collapsed?

MR. HILL:—We put a top boot on, the same as is done with any other car.

QUESTION:—How do you carry it in the car?

MR. HILL:—It usually is carried under the rear cushion.

Sheet Steel and the All-Steel Body

(*Concluded from p.* 170)

painting conditions, for there is a complete absence of raw metal edges on seams at which rust starts easily. The body is readily cleaned, and there are no sharp corners. This construction also makes for complete quietness in the body, since relative movement of clinched and welded parts is almost impossible.

In the older body-designs, in which a large number of stampings were used, the errors in the individual stampings might be cumulative when the stampings were assembled. Straining and forcing the parts was resorted to so that they might go together. With this new type of body, every corresponding door and window opening is of exactly the same size and shape, for they are closed sections in one piece of metal and depend for their shape only on the dies.

The diagrams in Fig. 3, serve to illustrate another desirable feature in this type of body. That at the right shows a body mounted in the conventional way on a narrow chassis-frame, with sill and splasher. The other shows the new type of body mounted directly on the chassis frame. It will be evident that the new type of fastening provides greater stability.

Casting Cylinders in Green Sand

By D. J. Campbell[1]

Annual Meeting Paper — *Illustrated with* Photographs and Drawings

Cylinder-blocks, with their hollow form and complicated arrangement of water-jackets, valve passages, pockets and bearings, are difficult to cast, and require a large quantity of cores. These have generally been baked or dry-sand cores, but the author's organization has met with success in making the more bulky cores, those for the cylinder-barrels and crankcase, in green sand. Descriptions and copious photographs and drawings are given of two methods of molding one six-cylinder block in green sand, and the possibilities of the system are indicated by illustrations of cylinders and details of cylinders that have been molded or that are suitable for molding in green sand.

Cooperation between designer and foundryman is essential in realizing the economy possible with this method of molding, a large part of which results from the great saving in cost of sand. Core-room and foundry layouts are given, also a comparative analysis of the cost of cores, made as far as practicable by the green-sand method, with the cost of dry-sand cores.

Foundrymen generally have such decided views as to the best way to secure both quality and production in the manufacture of cylinder-blocks that the advancement of one individual's views is almost certain to bring forth adverse criticism. I have therefore been reluctant to present this paper on foundry methods.

Green-sand molding, as applied to internal-combustion engines, has been thoroughly tried out in our own foundry and its practicability has been proved beyond a doubt. A substantial saving can be effected by following the green-sand method rather than the dry-sand method for cylinder-blocks, provided the castings are required in sufficient quantities to justify the added cost of equipment and the foundryman can have the full cooperation of the engineering department that is responsible for designing the cylinders.

The personnel of the corporation of which I have the honor of being the senior partner is made up of practical molders. Mr. Wyant, Mr. Cannon and I each served an apprenticeship in a different Chicago foundry during the years 1890 to 1896. Our experience as mechanics dates back to the early history of the gas-engine industry and embraces all branches of the trade, including loam molding, dry-sand molding and green-sand molding. Each of us has had also a thorough training and practical experience in core making. This combined experience qualified our company, which was organized in 1908, to take advantage of the demand for automobile castings when the large-scale manufacture of gasoline engines first began.

Cylinder-blocks were plainer and much more simple in this early period than now. Ample space was allowed for water-cooling, making possible larger and stronger cores. Much heavier thicknesses of metal were also allowed. Compared with present designs, those of the beginning of the industry seem crude; however, the castings were such that foundrymen, who were less experienced than now, found them almost impossible to produce. In the early period of the industry, all cylinder-blocks were made entirely in dry sand, which at the time proved the best and surest method for securing good results. Foundries had ample facilities for producing the castings in this way, as production was comparatively small.

As the industry expanded and the demand for greater production increased, the experience acquired by members of our company enabled us to venture, without fear of sacrifice in quality, into the green-sand method. Other foundries soon followed and have been making cylinders partly in green sand for the last 10 or 15 years. This means that they have been molding only the exterior parts of the cylinders in green sand, in the drag or lower part and the cope or upper part of the mold. This practice is commonly known to foundrymen as a two-part molding method. The practice of splitting the molds has been used for centuries, but the real art of green-sand molding, as applied to cylinder-blocks, carries the practice to cover most portions of the internal surfaces of the cylinders; in other words, replacing the dry-sand cores almost entirely with those made in green sand.

Pattern equipment required for producing the cylin-

TABLE 1—COMPARISON OF CORE COST FOR 500 CYLINDERS PER DAY IN BOTH GREEN AND DRY SAND AND IN DRY SAND

	Green and Dry	Dry Sand
Core-Department Investment	$100,000	$175,000
Investment, Carrying and Operating Charges, on Basis of 20 Per Cent of Investment and 200-Day Year, per day	$100.00	$175.00
Cores @ $8, 12 Tons	96.00	
66 Tons		528.00
Green-Sand Mixture, 54 Tons @ $5—75 Per Cent Reclaimed @ $1.25	67.50	
Transportation	20.00	30.00
Refuse Disposal	2.50	6.60
Total Cost	$286.00	$739.60
Daily Saving	$453.60	
Annual Saving, 200-Day Year	$90,720.00	
Saving per Cylinder	$0.9072	

[1] President, Campbell, Wyant & Cannon Foundry Co., Muskegon, Mich.

der-blocks by the green-sand method consists of several fundamental parts, including:

(1) Drag pattern
(2) Cope pattern
(3) Various crankcase core-boxes
(4) Cylinder-bore core-boxes
(5) Valve-push-rod-chamber core-boxes
(6) Flywheel-housing core-box
(7) Gear-end core-boxes
(8) Top and bottom water-jacket core-boxes
(9) Various valve-port core-boxes

Experience Gained with Three Designs

We have made three designs or models of cylinder-blocks during the last five years in green sand. They were for the engines used in the Star, Chevrolet and Pontiac cars. The casting of these cylinders has been carried considerably farther into the green-sand method of molding than is the usual practice, as we have formed the inside of the crankcases, the cylinder-bores and valve-push-rod chambers in green sand, in place of the usual dry-sand cores. This reduced the weight of our dry-sand cores by about 150 lb. per cylinder-block, leaving dry-sand cores required only for the gear-housing, flywheel-housing, water-jackets and valve ports. We made by this method about 10,000 Star cylinder-blocks like those shown in Fig. 1, 10,000 Chevrolet cylinder-blocks like those in Fig. 2, and 250,000 Pontiac cylinder-blocks like the one that is being loaded for shipment in Fig. 3.

Our experience and results on the Star and Chevrolet cylinders were especially good as to general results in both the foundry and the machine-shop, and the cylinders were highly satisfactory to the manufacturers who used them. The percentage of loss was very low. Results on the Pontiac cylinder, however, were not altogether to our satisfaction, due to several causes, but by no means entirely because of the green-sand method of molding.

We designed our equipment for molding the Pontiac

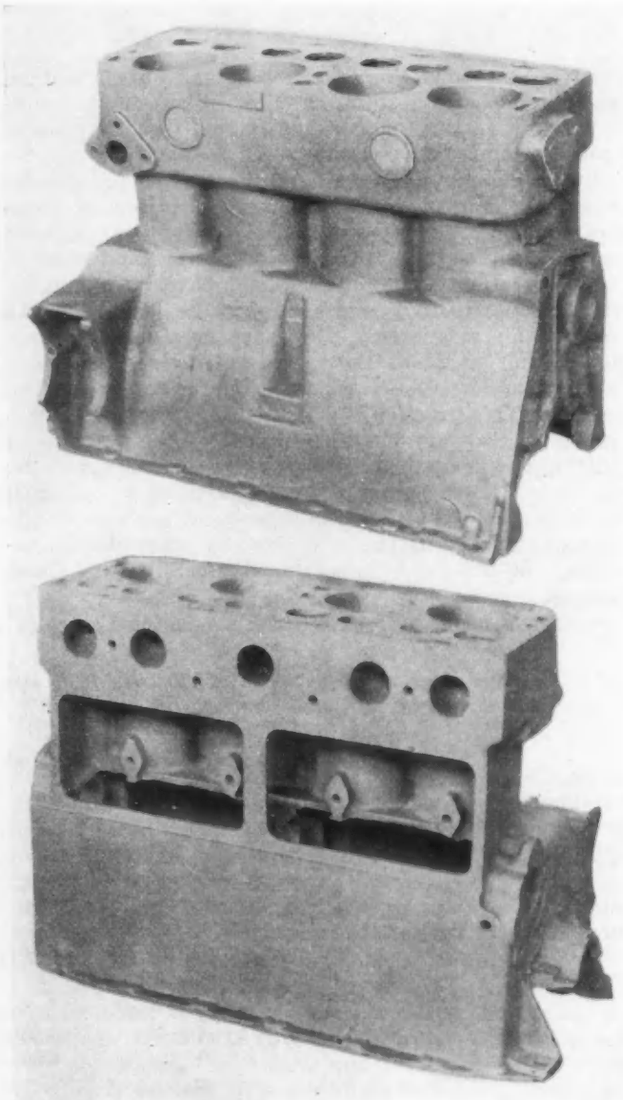


FIG. 1—TWO VIEWS OF THE CYLINDER-BLOCK FOR A FORMER MODEL OF THE STAR ENGINE

FIG. 2—TWO VIEWS OF A CHEVROLET CYLINDER-BLOCK CAST BY GREEN-SAND METHOD

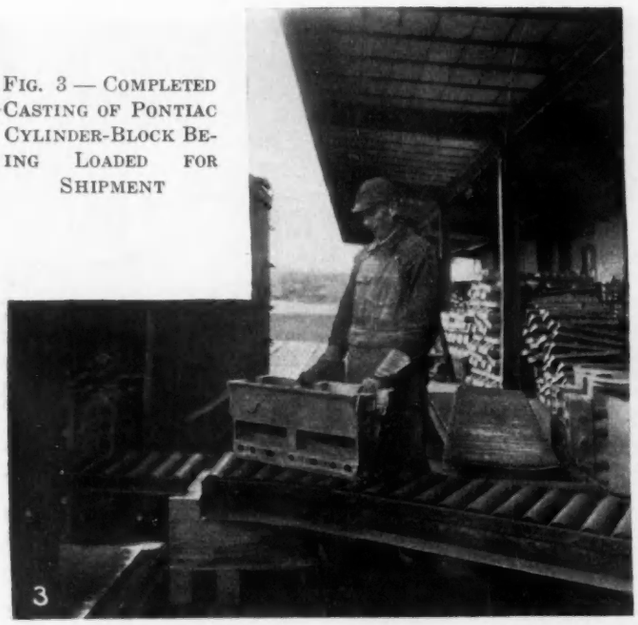


FIG. 3 — COMPLETED CASTING OF PONTIAC CYLINDER-BLOCK BEING LOADED FOR SHIPMENT

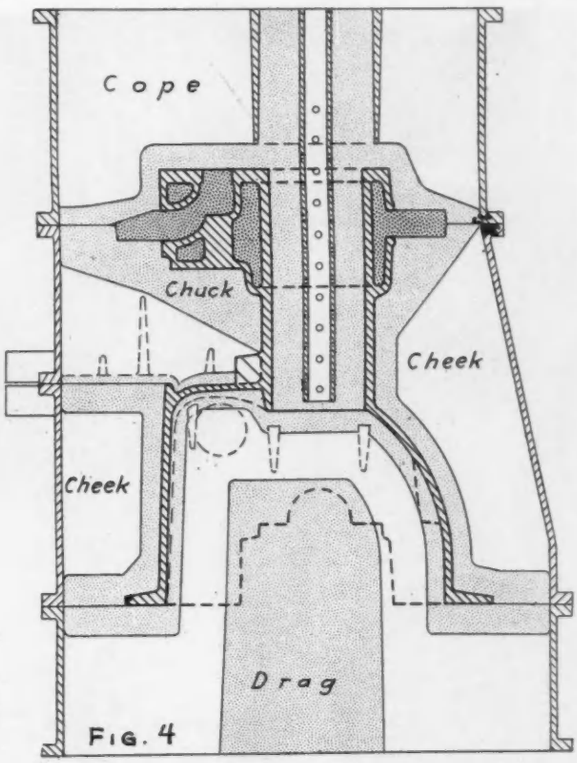


FIG. 4

FIG. 4 (RIGHT)—CROSS SECTION OF MOLD FOR PONTIAC CYLINDER

In This Layout, the Cylinder Was Cast Vertically. The Cores for the Cylinder and the Valve-Push-Rod Chamber, as Well as That for the Crankcase, Were Made in Green Sand. The Upper Part of the Mold Was Stripped While the Casting Was Hot, To Condense the Metal

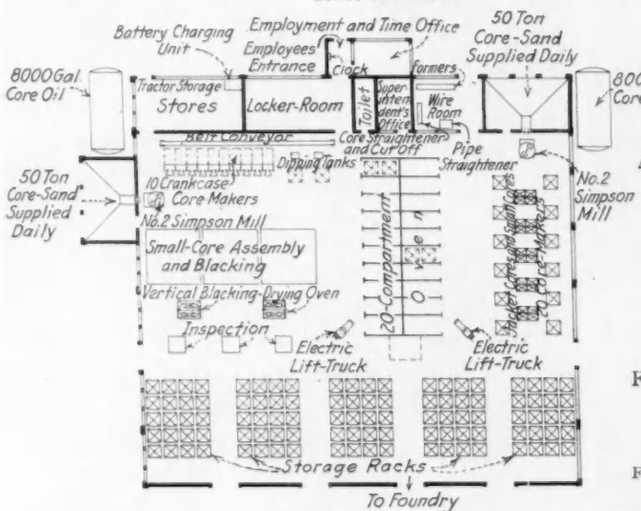


FIG. 5

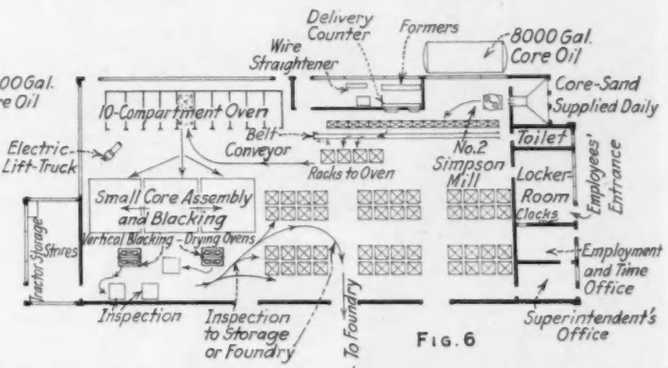


FIG. 6

FOUNDRY SPACE AND EQUIPMENT REQUIRED FOR PRODUCING 500 CYLINDERS PER DAY

Fig. 5—Core-Room for All-Dry-Sand Cores
Fig. 6—Core-Room for Green-Sand and Dry-Sand Cores
Fig. 7—Foundry Floor-Space for Use in Connection with Core-Room Shown in Either Fig. 5 or Fig. 6

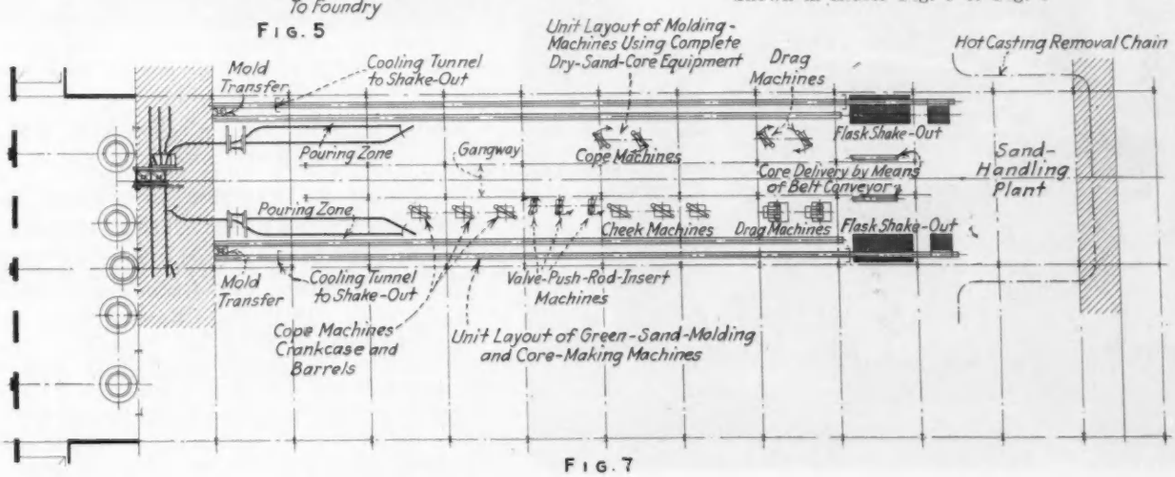
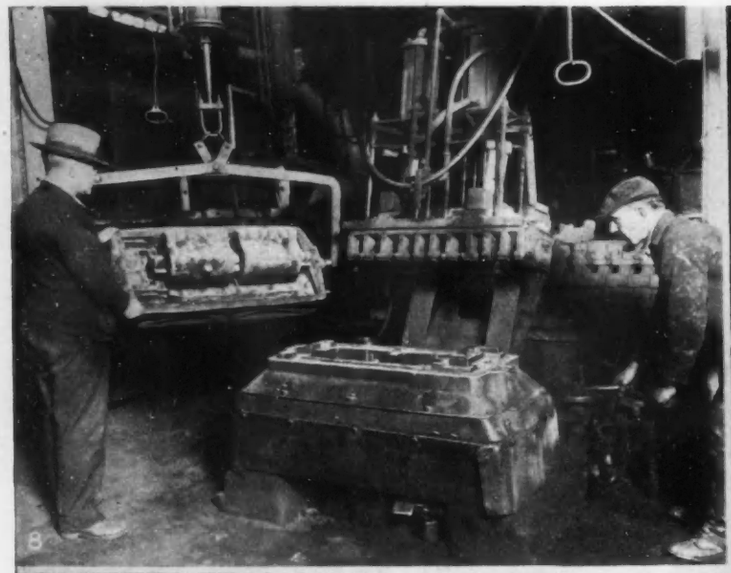
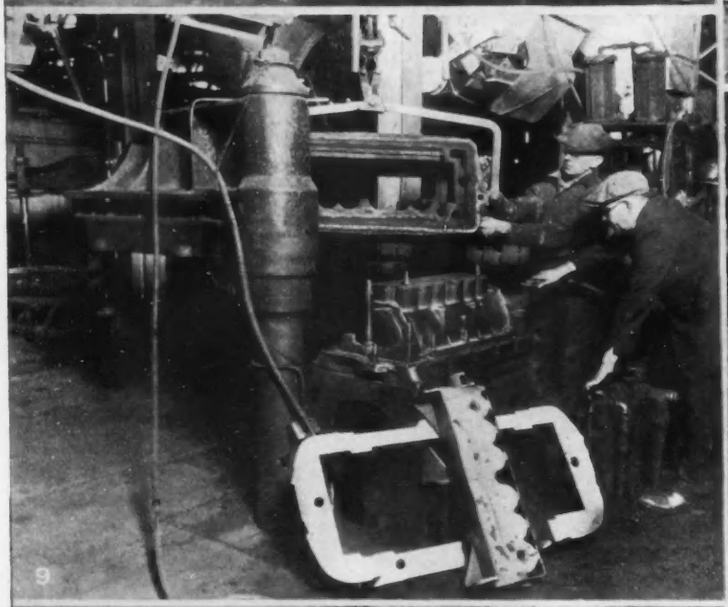
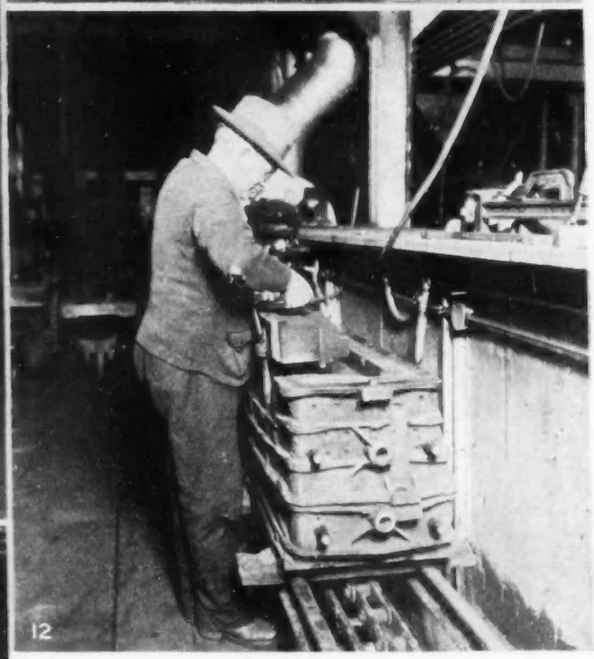
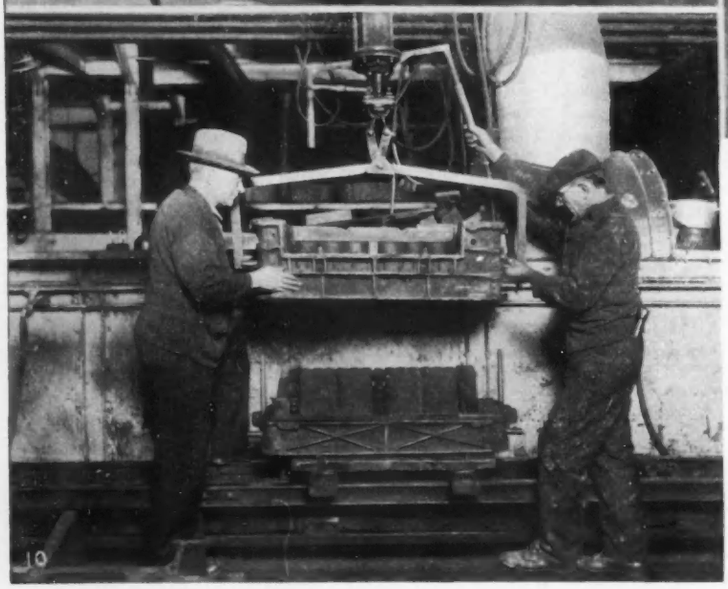


FIG. 7









FORMER MOLDING METHOD FOR PONTIAC CYLINDERS USING LAYOUT SHOWN IN FIG. 4

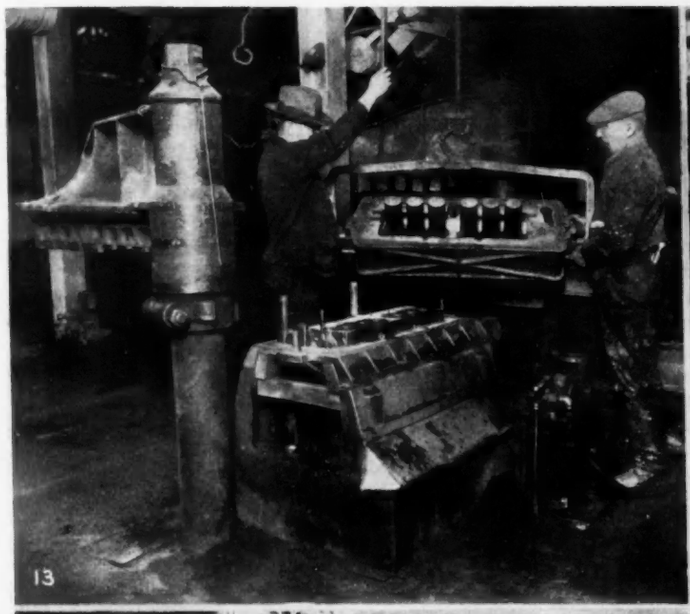
FIG. 8—MAKING DRAG MOLD IN MOLDING-MACHINE

FIG. 9—MAKING CHEEK MOLD IN GREEN SAND

FIG. 10—PLACING CHEEK MOLD ON DRAG

FIG. 11—PATTERN AND GREEN-SAND MOLD FOR PUSH-ROD CHAMBER

FIG. 12—FITTING MOLD FOR PUSH-ROD CHAMBER INTO THE CHEEK MOLD



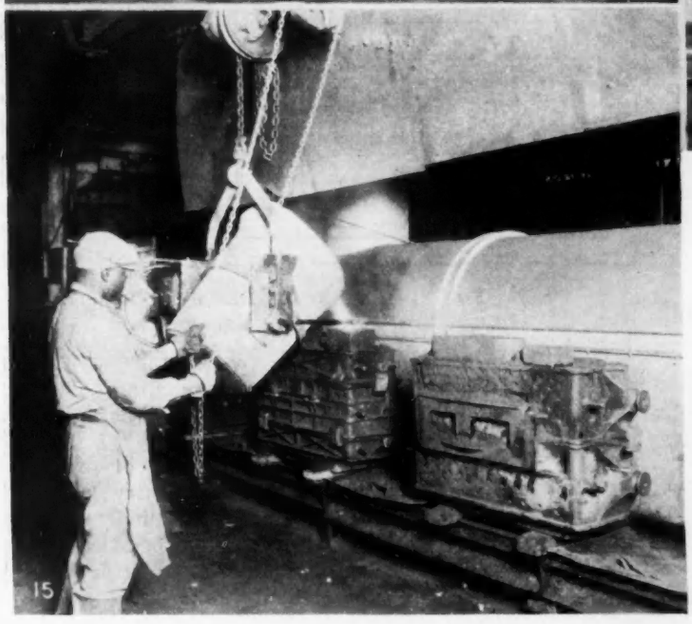


FIG. 13—COPE MOLD WITH GREEN-SAND CYLINDER CORES

FIG. 14—CLOSING COPE MOLD ONTO CHEEK

FIG. 15—POURING, AFTER CLOSING AND CLAMPING MOLD

cylinder with the idea of casting it in a vertical position, with the head end uppermost, as shown in Fig. 4. This was done for the purpose of stripping and exposing the surfaces of the cylinder-barrels and valve-seats while they were hot, to secure fast cooling and cause the iron to densify. Numerous tests showed that this procedure actually did close up the grain of the metal and improve the condition of the barrels and valve-seats. However, we abandoned this practice, for several reasons, and accomplished the same results by adding alloys in the ladle before pouring the metal into the mold.

Design Must Be Adapted to Process

The experience we gained from these particular jobs was very encouraging and will be of much benefit in designing future equipment for casting cylinder-blocks in green sand. We feel that the future development of green-sand methods on cylinder-block production will prove economical and is worthy of much careful consideration by engine designers.

Not all cylinder-blocks lend themselves to this method, especially with some present designs of crankcases, cylinder-bores, and valve mechanism. The future development of green-sand molding depends to a large extent on the cooperation of engineering departments in so designing their cylinder-blocks as to make it possible for the foundryman to make them by this method. Flanges, ribs, lugs, or other projections may defeat the desire of a foundryman to use the green-sand method.

Extending the use of green sand further into the making of the interior surfaces of the cylinders requires considerably more experience and foundry knowledge of equipment on the part of supervision and management than do the more familiar methods, and the chances for success are greatly influenced by the molding-machines and other equipment and the materials selected or developed. The advance made in molding-machine design and machine equipment during the last 10 years contributes greatly to the success of the process. Much credit should be given also to the advanced knowledge and guidance given the foundryman by the laboratory in the standardization of better molding-sand and other molding materials. We are enthusiastic about the possibilities of green-sand molding as applied to cylinder-blocks that are properly designed to meet the requirements of this method.

Present production methods for machine-molding require the pattern to be so constructed that it has no drawbacks or loose pieces, as they interfere with the jolting and squeezing operations commonly used in making the mold. Formerly, when a design was developed by an engineering department, the next step was to pass the drawings on to the pattern-maker, who was supposed to possess a secret and treasured knowledge of the best way to split up the pattern and mold the cylinder as designed by the engineering department. This was largely due to the ability which the pattern-maker possessed of being able to read and understand drawings. Today, many foundrymen in the automotive industry possess this knowledge in addition to their experience and knowledge as foundrymen. The best results are obtained in the development of a cylinder-block for the highest possibilities of production by the combined knowledge of the engineering department, the pattern-maker and the practical foundryman.

Parting Line and Pouring Position

The almost universal practice, in planning cylinder-block pattern-equipment, is to split the pattern through the bore center and mold in a horizontal position in a two-part flask. This is not always the only way or the most advantageous way in which the casting can be made. Any one of four ways can be used, according to whether it is to be made in dry or green sand. The fundamental idea in the foundryman's mind has always been to use the most advantageous way of procuring clean bores. However, the cylinder is required to be clean all over and to meet high tests; sound castings must be produced regardless of the position in which the pattern is parted for molding. Therefore it is optional which way the pattern is split.

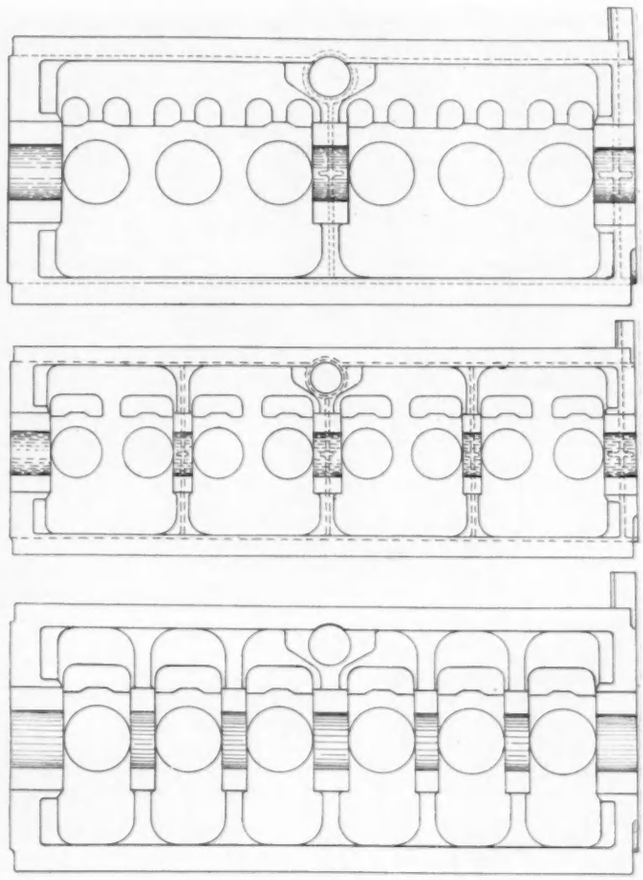
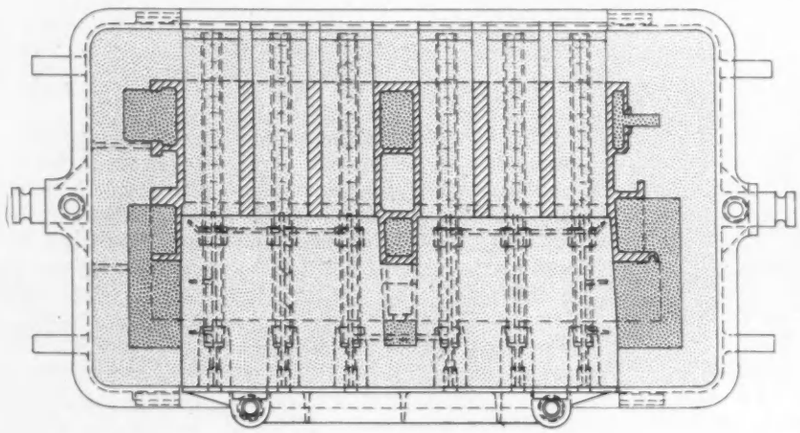


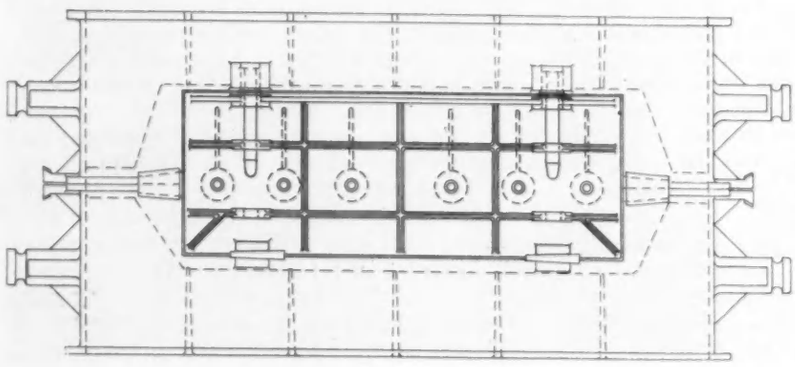
FIG. 21—CRANKCASE DESIGNS SUITABLE FOR MOLDING IN GREEN SAND

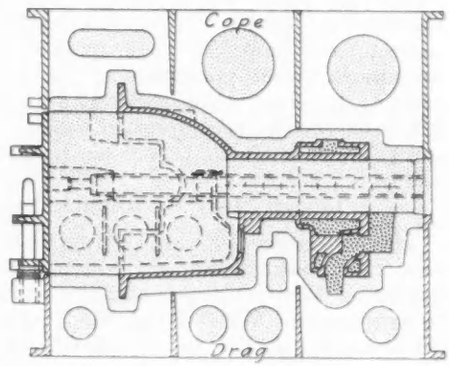


The foundryman's problems of producing any cylinders, whether in dry sand or green sand, are many, but chief among them are temperature, hydrostatic pressure, velocity of molten metal in pouring, and gas and steam. Molten metal at a

FIG. 16—MOLD FOR CASTING PONTIAC CYLINDERS IN HORIZONTAL POSITION

This Method of Casting Superseded the Vertical Method Shown in Fig. 4 and Figs. 8 to 15





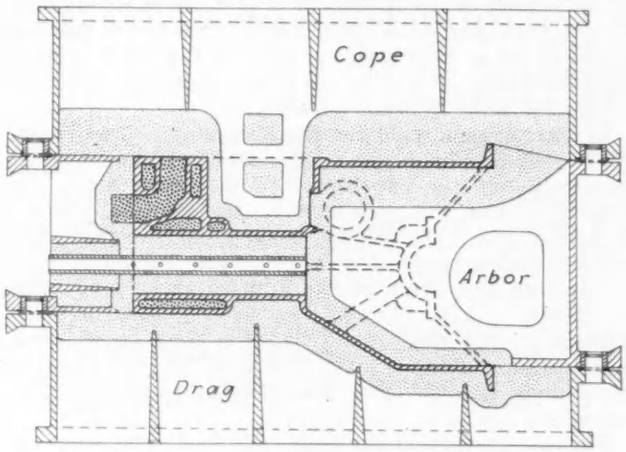


FIG. 17

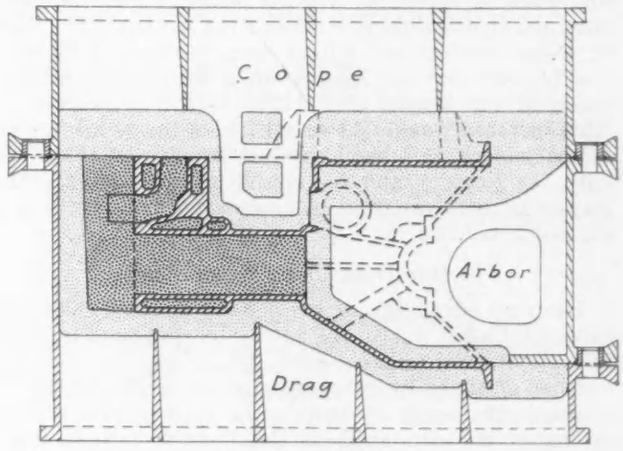


FIG. 18

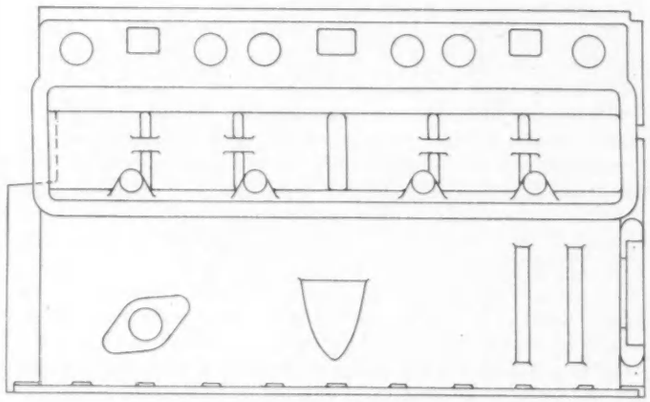


FIG. 19

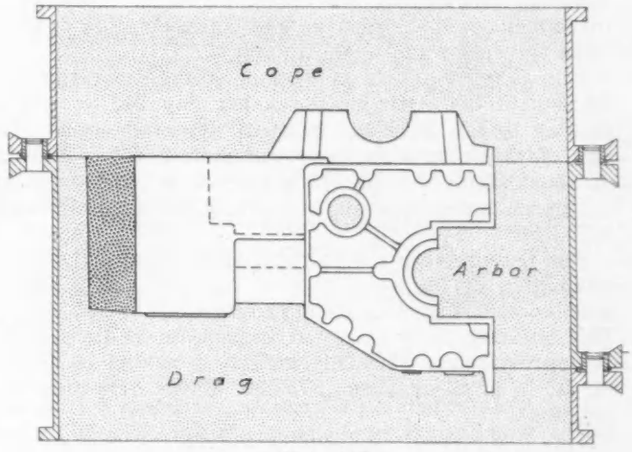


FIG. 20

FIG. 17—SUGGESTED GREEN-SAND CYLINDER-BLOCK MOLD
FIG. 19—PATTERN FOR MOLDING THE CYLINDER SHOWN IN FIGS. 17 AND 18

FIG. 18—MOLD FOR SAME CYLINDER AS SHOWN IN FIG. 17, WITH DRY-SAND CORE FOR CYLINDER-BARREL AND SLAB
FIG. 20—A CYLINDER DESIGN FOR SIMPLIFIED CASTING

temperature of 2600 to 2700 deg. fahr. has a tendency to destroy all molding material by fusing or disintegrating it; and the hydrostatic pressure and weight of the metal have a tendency to strain or distort molding materials, especially at delicate corners which are not large enough to be secure against temperature, velocity and pressure.

The heat generates steam from the moisture used in the molding mixture and gas from the molding materials. This steam and gas must be allowed to escape freely, without creating an internal pressure. If some provision is not made to relieve this pressure, the mold is generally destroyed and defective castings result. The great care that must be exercised in providing for the free escape of steam and gases to the atmosphere is one of the principal reasons why the use of green-sand molding is limited and depends on engineering designs and construction. Making water-jacket cores or valve-pocket cores in green sand would be impracticable for this reason, as the percentage of exposed surfaces is generally too small to serve as an outlet, and the section of sand is too delicate to be secure. These parts of the mold must still be made in cores of dry sand, in order to remove all possible moisture and gas before the cores come into contact with molten metal while casting.

Importance of Liberal Water Spaces

Knowledge and experience qualify expert foundrymen to produce the most complicated and intricate cylinder designs provided that cost is a secondary consideration. During our 20 years of experience in casting cylinder-blocks of many makes and models, we have experienced much trouble in trying to comply with the requirements of different engineering departments. Most of these could have been avoided, or at least considerably lessened, by more liberal provision in the designs for water-jacket space around valves, between the bores, and elsewhere. Some of our experiences in years gone by have caused us much expense and loss, on several occasions nearly putting us out of business.

We have observed a general tendency toward cylinder-blocks of condensed or compact designs which has caused much trouble for the foundryman in producing good, efficient results as a commercial foundry practice. The resulting water spaces are too intricate or delicate,

and molding materials will not withstand the temperature and hydrostatic pressure of the molten iron. Most of these troubles could have been avoided by allowing the foundryman the leeway of a fraction of an inch more in the length and width of the cylinder-block. This increase would add very little to the weight of the cylinder-block and would reduce trouble and loss for both the foundry and the engine manufacturer. This leeway is more essential in green-sand molding than in dry-sand molding.

Saving from Using Green Sand

The real advantage of green-sand molding over dry-sand molding is due to the saving of core-sand material by substituting molding-sand, which can be used any number of times by reconditioning at a very small expense, for core-sand, which can be used only once. This saving of core material on the Pontiac cylinder-block amounted to 110 lb. per casting, at about 0.8 cents per lb. In addition, there was a saving in the expense of handling and drying the cores, which is costly as to investment in the core-room and transportation of cores from the core-room to the foundry.

Fig. 5 represents a core-room suitable for the production of 500 cylinder-blocks per day for an engine similar to the Pontiac, using all-dry-sand cores. The size of this core-room is approximately 150 x 160 ft., or about 25,000 sq. ft. This core-room building, fully equipped, represents an investment of approximately $175,000.

Fig. 6 represents a core-room large enough for equal production of the same type of cylinder, using green-sand cores. The area is approximately 15,000 sq. ft. This building, fully equipped, represents an investment of approximately $100,000, making a saving of 10,000 sq. ft. in area, or about $75,000 on the core-room investment.

Fig. 7 represents a foundry layout for making 500 cylinder-blocks per day by either the green-sand or dry-sand method. The floor space required is the same in either case. Table 1 is a condensed summary of the core cost and the core transportation expense involved in producing 500 cylinder-blocks of approximately the size of the Pontiac cylinder. This shows a daily saving of $453.60, and a saving per cylinder of approximately 91 cents.

Fig. 8 is a photographic view of the molding machine in its location while making a drag mold in green sand for the Pontiac cylinder-block; Fig. 9 shows the making of the cheek mold in green sand, and Fig. 10 is a view of the operation of closing the cheek mold onto the drag, all for the same Pontiac cylinder.

The green-sand mold for the Pontiac push-rod chamber is seen in Fig. 11, and Fig. 12 shows the fitting of this mold into the upper part of the cheek mold. In Fig. 13 is seen the cope mold of the Pontiac cylinder in green sand, with the green-sand barrel-cores made and suspended, ready to be set in place.

The drag and cheek of the Pontiac green-sand mold are shown in Fig. 14, with the water-jacket cores assembled in the cheek mold and the cope mold being closed onto the cheek mold. In Fig. 15, the mold is closed and clamped and the molten metal is being poured.

Fig. 16 shows vertical and horizontal cross-sections and an elevation of another layout for casting the Pontiac cylinder-block, this time in a horizontal position. This method was substituted for the vertical position shown in Fig. 4 and Figs. 8 to 15. The cylinder cores are still made in green sand.

Fig. 17 shows a suggested mold for casting a cylinder-block in green sand, with the valve-push-rod chamber in the cope mold and the main parting line of the mold at the flat side of the cylinder, which lies uppermost in the mold. It also shows the crankcase cores suspended on a lifting arbor, which is a section of the drag mold, and indicates the possibility of substituting for the usual slab core a green-sand mold which carries also the barrel cores. The same layout is shown in Fig. 18, with the exception that the slab core and barrel core are made as one dry-sand core instead of in green sand. A plan view of the cope pattern, which would be the same in either case, is shown in Fig. 19.

In Fig. 20 is shown an end view of a proposed cylinder with the gear-housing reduced in height to simplify the molding. This design reduces the height of the flask and the hydrostatic pressure of the molten metal, because no additional pouring basin is needed, the depth of the cope giving sufficient head. Fig. 21 shows three types of crankcase that can be molded in green sand. One is for a six-cylinder engine having three main bearings; the second is for an eight-cylinder engine having five main bearings; and the third is for a six-cylinder engine having seven main bearings.

The Application of Motor Transport to Passenger Movement

By FREDERICK C. HORNER[1]

TRANSPORTATION MEETING PAPER[2] *Illustrated with* PHOTOGRAPHS AND CHARTS

THIS paper constitutes Part II of the general subject of the application of motor-vehicles to the movement of freight and passengers, as treated by Mr. Horner.

Herein the author presents a comprehensive picture of the present status of motorcoach transportation in the United States. He shows by data and charts the great growth in the last decade in the number of motorcoaches operated, the mileage covered and the passengers carried. These figures are compared with similar data for rail transportation and with increase in population. While the number of passengers carried by motorcoaches is shown to have increased enormously since 1917, the traffic on electric and steam railways has decreased considerably. The rail lines are endeavoring to recapture the lost passenger traffic by operating motorcoach lines themselves, either directly or through subsidiary companies or through working arrangements with independent motorcoach operating companies. Such service is conducted to entirely replace steam-train or electric-car operation in some cases, to supplement fast long-distance train or car service, or to serve as feeder lines. Some operating cost figures are given to show the relative economy of motorcoach operation as against steam-train service.

Long-distance motorcoach lines, which connect most of the cities and large towns from the Atlantic to the Pacific Coast and from the Canadian to the Mexican border, are growing into important interstate and national systems. As an example of the recognition of the importance of comfort and convenience, the author shows and describes a special coach for night travel provided with sleeping compartments, arrangements for cooking and serving meals, and other conveniences comparable with those of Pullman railroad trains.

The extent to which city transportation service is rendered by motorcoach is shown in tabular form as well as in text, and examples are given of operating costs and revenues.

The latter part of the paper is devoted to considerations of the causes of delays in service, taxation of motor-trucks and motorcoaches, and restrictions imposed for the protection of highways and users thereof.

MOTORCOACH transportation under proper regulation, scientifically applied and operated, is today a public convenience and necessity. With public understanding and cooperation, the usefulness of the motorcoach may be developed to a very high point consistent with public welfare and public service. Motorcoach transportation is not only flexible but is inherently convenient. Combining these elements with economy, the picture of motorcoach transportation is complete. The motorcoach presents the cheapest form of commercial travel in America, as the average rate of fare in the United States is approximately 25 per cent lower than for travel in any other commercial vehicle. Basing the gross value of the Nation's motorcoach transportation business of 1927 in excess of $300,000,000, motorcoach transportation saved the travelers of the United States at least $100,000,000.

We are coming to realize the pleasure, convenience and economy of motorcoach transportation; the farmhouse becomes a motorcoach station and the motorcoach line becomes the rural railroad, the development thus becoming a community asset.

Transportation by motorcoach is usually divided into two major classes: interurban or intercity service, under which come the short-haul and the long-haul carrier; and urban, or city, service. As a part of both classes, we then have motorcoach transportation as coordinated with the steam and electric railways. Still other subdivisions of motorcoach transportation service that are now well defined are the school, sightseeing, and charter-hire types of service.

As early as 1912 a few motor buses locally known as "stages" were in use in the far-western part of the United States, but they were used more for sightseeing than for ordinary transportation purposes. On Jan. 1, 1926, the number of motorcoaches in operation had grown to 70,000, and three years later, Jan. 1, 1929, more than 92,400 were in operation in the United States, of which 40,875 are school buses. On the latter date the mileage on scheduled routes was 719,500, as compared with 249,644 route miles of steam railroads. Of this motorcoach mileage, 289,473 miles are classified as common-carrier routes, the remaining 430,027 miles being devoted to sightseeing, hotel and school routes.

Rapid-transit companies such as interurban electric lines and city railways now own large fleets of motorcoaches, while the steam railroads, with a few exceptions, have only recently seriously considered the motorcoach, with the result that some of this more profitable traffic has been lost to the independent motorcoach line. Now, however, a large number of the steam railroads are doing their best to recapture this traffic by establishing motorcoach lines in their respective territories. The loss of passenger traffic by the railroads will not easily be recaptured, if it ever is; for, though the motorcoach rider who has been attracted by the lower

[1] M.S.A.E.—Assistant to vice-president, General Motors Corp., New York City.

[2] Written for presentation at the World Engineering Congress, Tokio, Japan. For Part I see S.A.E. JOURNAL, Dec., 1929, p. 611.

TABLE 1—INCREASE OR DECREASE[a] IN POPULATION AND PASSENGER TRAFFIC ON RAIL AND MOTORCOACH LINES IN THE UNITED STATES

	First 5-Year Period 1912 to 1917	Per Cent	Second 5-Year Period 1917 to 1922	Per Cent	Third 5-Year Period 1922 to 1929	Per Cent
Population	7,075,547	7.5	7,075,548	6.9	9,379,607	8.6
Common-Carrier Passengers	2,434,129,985	18.5	1,575,256,009	10.1	1,550,773,676	9.1
Rides per Capita	14.34	10.4	4.5	2.9	6.6	3.9
Passengers Carried by						
Steam Trains	62,557,128	6.1	*99,229,269*	*9.2*	*92,826,473*	*9.7*
Surface Electric Lines	2,101,744,147	18.8	353,969,892	2.6	*400,044,561*	*3.0*
Rapid-Transit Lines	269,828,710	23.0	470,515,886	37.0	368,644,210	21.0
Motorcoach Lines	.....	...	850,000,000[a]	...	1,674,000,000	197.0

[a] Decrease indicated in italics.
[a] First authentic record.

fare, the more convenient service, and the better opportunity to see the beauty of the Country and the attractions of the cities, may change over for one reason or another to rail facilities, nevertheless the rapid progress being made in giving still better motorcoach transportation service will make it more popular than ever before.

One important field that can be served admirably by the motorcoach seems to be the short-haul transportation of passengers in limited volume. For city service, double-deck vehicles such as that in Fig. 1, carrying as many as 70 passengers, and for the rural and suburban districts, single-deck vehicles carrying 15 to 40 passengers, are replacing small branch-line steam trains and interurban electric cars. This type of service can well be termed "retail" transportation. Rapid-transit lines, subways and elevated electric roads, in the cities, commuters' trains in the suburbs, and long-distance express trains furnish "wholesale" or train-load transportation and cannot economically be replaced by highway transportation.

Statistics of Motorcoach Transportation

To enable you to quickly grasp the importance of the motorcoach as a passenger-carrying vehicle, I must resort to statistics; and so that you may have a comprehensive picture of the evolution of this type of transportation during the last five years, I present herewith some basic facts as compiled from various sources but principally *Bus Transportation*, the leading American publication on the subject as its name implies. These

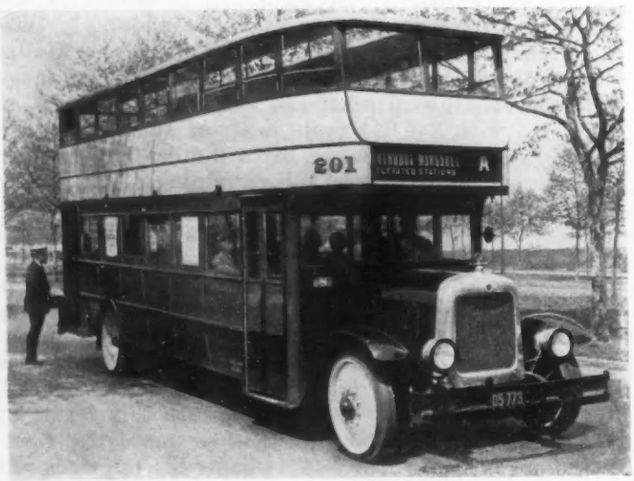


FIG. 1—TYPE OF DOUBLE-DECK MOTORCOACH USED FOR METROPOLITAN SERVICE

figures show that rapid progress is being made toward stabilizing motorcoach transportation to such an extent that it will be just as important a part of our transportation structure as the steam and electric railways; in fact, it would not be an exaggeration to say that, for certain classes of service, that goal already has been reached (See Fig. 2).

As evidenced by Table 1, the advent of the motorcoach has very materially changed the riding habit of our people. The figures indicate clearly the truly phenomenal growth of motorcoach transportation in the United States during the last decade.

The short-haul intercity and intrastate motorcoach service is still more impressive in the volume of miles and passengers carried, the figures showing 4,085,000,000 passenger-miles of transportation sold and 292,000,000 passengers carried during 1928. Some form of motorcoach service is operated between all cities and towns of any size, and these services are continuously being improved. Here I would point out that the more convenient and comfortable we make any form of transportation service, granted the traffic is present, the greater the riding habit will become (See Fig. 3).

According to the latest figure compiled by *Bus Transportation*, as of Jan. 1, 1929, slightly more than one-half of the 1032 cities in the United States having a population of more than 10,000 had some form of local motorcoach service. Of approximately 526 such cities reporting bus service, 153 or 29 per cent had no other means of public transportation than buses, taxicabs and private automobiles. In London, the motor omnibus is such a big factor in the city transportation picture that nearly 5000 are in daily service and, during 1928, carried more than 1,250,000,000 passengers. Although we have nothing in the United States to compare with this operation, still, as shown in the table, our city-service bus occupies a very important place in our city-transportation structure. It has made a real contribution to the new demands caused by changed conditions. New sections of cities have been opened, creating new transportation demands which have been filled by the city-type motorcoach. Feeder lines, coordinated with electric railways and main-line motorcoach service, have, taken together, come to be as necessary a part of the transportation facilities of most of our cities as the streets on which the electric car, the bus and the automobile operate.

Motorcoach Operation by Railways

More than 300 electric-railway companies in the United States and Canada are now operating approximately 10,700 motorcoaches covering more than 20,000

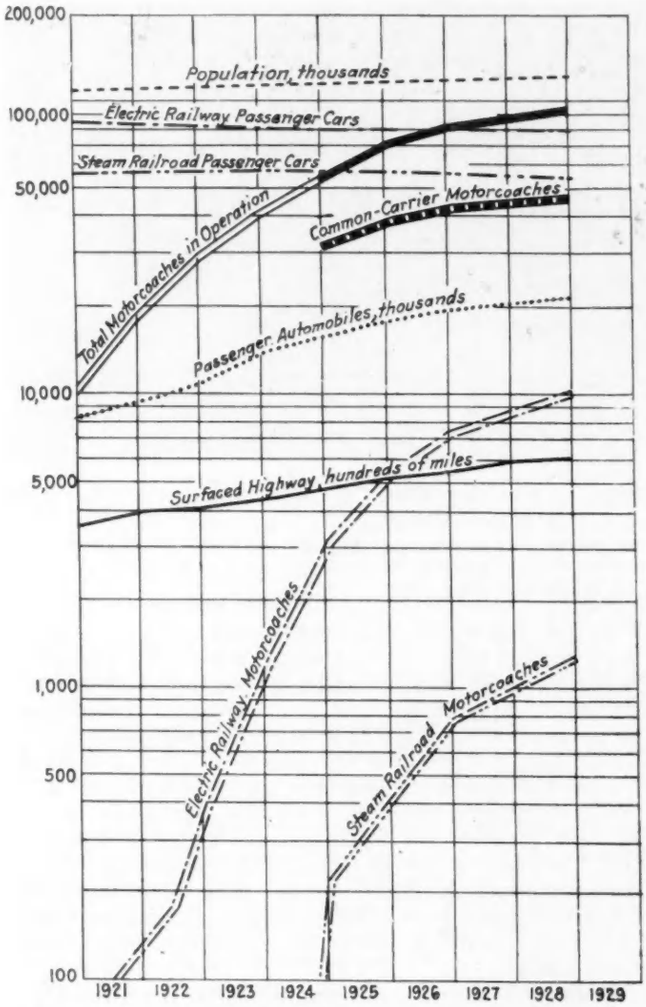


FIG. 2—INCREASE IN MOTORCOACHES IN OPERATION COMPARED WITH STEAM AND ELECTRIC RAILWAY PASSENGER-CARS

route-miles in conjunction with their rail service. Some 50 additional companies have entirely replaced their electric-car service, using more than 500 motorcoaches for this purpose (See Fig. 4). The motorcoaches owned by all these companies were operated an aggregate of 300,000,000 miles during 1928 and carried more than 1,000,000,000 passengers.

In some cases in the railroad field the motorcoach is limited to sparsely settled districts where there is not sufficient traffic to justify the operation of passenger trains. But in some other districts local passenger service can best be performed by motorcoaches in conjunction with express-train rail service. Motorcoach transportation should be encouraged by the railroads wherever it fulfills the public need, and the railroads shold adopt it whenever it offers the most economical method of transportation. If the public prefers to "ride on rubber" it will do so, although in some cases part of the price it must pay must be a reduction in rail service. Some of our railroads are endeavoring to direct the public's riding habits along economic lines, supporting independent highway transportation lines in their legitimate field but not hesitating to provide their own motorcoach service where it has proved to be the transportation tool that best meets the requirements.

The railroads are using motorcoaches in several ways, the most important of which are:

(1) In replacement of local train service
(2) As additional service auxiliary to local train service
(3) As additional feeder service to make local stops between zone points of fast trains
(4) As feeder lines
(5) In carrying employes to and from railroad shops
(6) As train-connection service in terminal cities, as at New York City
(7) In touring service to summer resorts, National parks, and so forth.

Service of the types mentioned in items (6) and (7) have been furnished by the railroads for some years. Item (6) is best exemplified by the operation of the Baltimore & Ohio Railroad motorcoaches, which take passengers from the company's rail terminus direct to hotels or motorcoach stations in the heart of New York City and Brooklyn. Notable examples of item (7) are the services of the Boston & Maine, Santa Fe, Union Pacific and other railroads to resorts and National parks. In general, the railroads have found it best to conduct their motorcoach operations themselves, or through contract with existing motorcoach operators, or through a subsidiary company organized by the railroad company. Operation by a subsidiary company has become very popular and is the most general practice.

The steam and electric railroads are making money in two ways by using motorcoaches; first, by reducing losses on unprofitable train-operations and, second, through actual increase of passenger revenue from motorcoach lines acting as feeders and supplementary to long-distance rail service. An exceptional case is one in which a steam railroad is saving more than $25,000 per year where one motorcoach replaced a daily train. The railroad companies' solution of the short-haul passenger-service problem in many places is to give motorcoach service, by buying out independent motorcoach lines, by contract, or through a stock partnership in well organized motorcoach companies that are rendering a necessary and convenient transportation service in their territories.

At present 23,300 companies, including independent operators as well as electric and steam-railroad com-

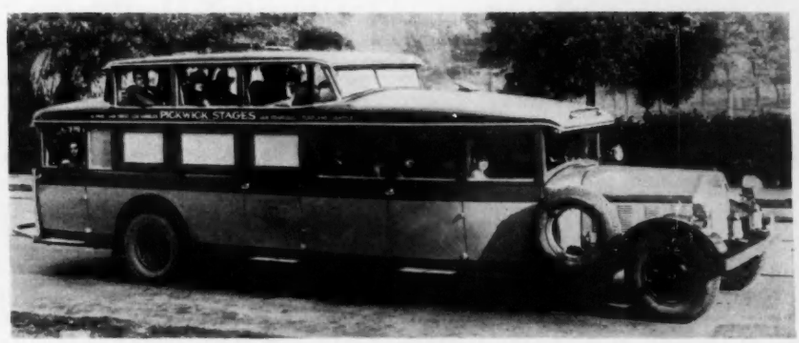


FIG. 3—OBSERVATION-TYPE INTERCITY MOTORCOACH WIDELY USED ON LONG-DISTANCE ROUTES THROUGHOUT THE COUNTRY

panies, are operating such service. During 1928, motorcoaches of these companies carried more than 1,793,000,000 passengers. Obviously, the development of so vast a system of transportation is certain to have its effect upon the steam and electric railways. Since motorcoach traffic reached a great volume in 1925, passenger traffic on the railroads has steadily declined. This is due largely to the private automobile, as only a small portion of the railroad traffic was lost to the motorcoach. The number of motorcoaches operated by steam railroads increased from scarcely 200 at the end of 1924 to more than 1200 in 1929, and now more than 62 railroads maintain motorcoach service. The electric-railway industry was not so slow to adopt this form of transportation, and already more than 50 per cent of our electric railways operate motorcoaches.

To operate a small local train one mile costs approximately $1.25, as compared with 25 to 30 cents per mile for the motorcoach. For the railroad, these are out-of-pocket costs only and do not include fixed charges, roadbed maintenance, and the like. Thus the ratio is not far from 5 to 1 in favor of the motorcoach. For a steam train the average fuel cost is 23 cents per mile, while for the motorcoach it is 3 cents per mile. Wages per mile for the motorcoach are 4 cents as compared with 28 cents for the train. The Boston & Maine Railroad found that the cost per mile of operating a steam passenger-train, without any charge for road-bed or rail maintenance, was $1.59; of rail-cars, 72 cents; and of motorcoaches, 29 cents.

Rail and Highway Transport Coordinated

Real progress has already been made in applying the motorcoach to railroad requirements, and the railroad officials from high to low are earnestly striving to properly coordinate the two transportation facilities. One of the most interesting and successful cases in which this has been done is at New York City.

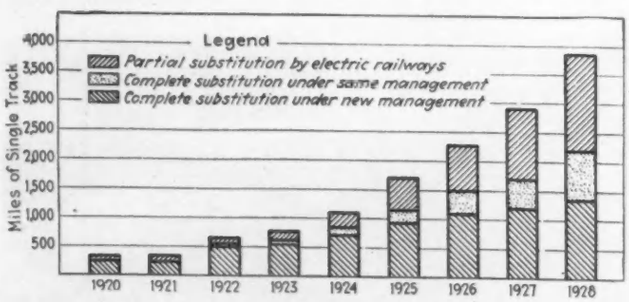


FIG. 4—CUMULATIVE REPLACEMENT OF ELECTRIC-CAR SERVICE BY MOTORCOACH SERVICE

In the Last Nine Years Motorcoach Lines Have Replaced Electric-Car Operation on 3850 Single-Track Miles of Electric Road

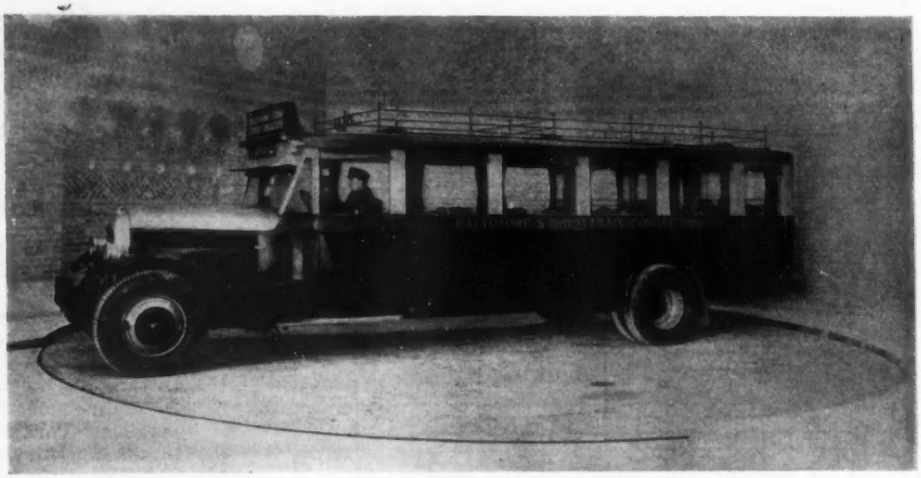


FIG. 5—MOTORCOACH TURNTABLE IN THE NEW YORK CITY TERMINAL OF THE BALTIMORE & OHIO RAILROAD

The Terminal Is Located in the New Chanin Building Opposite the Grand Central Station. The Motorcoaches Carry Passengers to and from the Railroad Terminus in Jersey City on the West Side of the Hudson River

A new and more convenient way of carrying passengers to and from the center of New York City was inaugurated on Aug. 29, 1926, by the Baltimore & Ohio Railroad. This innovation was typical of the pioneer achievements of America's first railroad and of the vision and leadership of its president, Daniel Willard. Under the new arrangements, the Baltimore & Ohio trains terminate their runs on the west bank of the Hudson River at the main station of the Jersey Central Railroad, in Jersey City, N. J., from which point the Baltimore & Ohio special parlor motorcoaches transport passengers through the business, shopping, hotel and theatrical districts of Manhattan without extra charge.

Commodious and comfortable motorcoaches which provide individual seating for each passenger and space for hand luggage, run directly from the train-side at Jersey City by way of ferry to lower Manhattan and thence to the Baltimore & Ohio motorcoach terminal in the Chanin Building on 42nd Street in the heart of New York City just opposite the Grand Central Station. Sub-terminals at which these motorcoaches make regular stops are located at strategic points on the routes followed.

The terminal at the Chanin Building is the most modern design of motorcoach terminal in the world. The coaches are driven into the building on the ground floor, just as a train enters the train shed of a modern railroad terminal. After discharging the passengers, they are turned on electrically operated turntables, as shown in Fig. 5, and in a few minutes are ready for a return trip to the rail terminal at Jersey City.

As one prominent railroad official stated recently, "Better coordination of rail and highway transportation offers benefits not only to the carriers but to the public, whose interest must always be considered as paramount."

One of the notable motorcoach transportation developments promoted by a steam railroad is that of the New England Transportation Co., operating over 61 routes covering 2200 route-miles in an area of approximately 30,000 square miles. The company is a

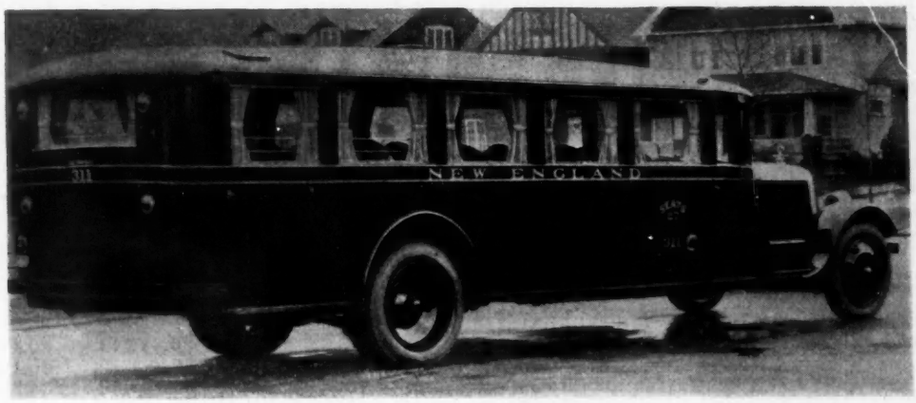


FIG. 6—PARLOR-CAR TYPE OF 27-PASSENGER SINGLE-DECK MOTORCOACH OPERATED BY THE NEW ENGLAND TRANSPORTATION CO.

The Operating Company, Which Is a Subsidiary of the New York, New Haven & Hartford Railroad, Operates More than 300 Motorcoaches over 61 Routes Covering 2200 Route-Miles in an Area of Approximately 30,000 Sq. Miles

subsidiary of the New York, New Haven & Hartford Railroad and, according to the officials of that company, has been very successful from the standpoint of revenue production as well as in reducing losses on unprofitable passenger trains by using the motorcoach as a substitute for or to supplement the trains.

This railroad motor-transport company operates more than 300 motorcoaches and employs 500 men. In 1928 it operated 9,000,000 motorcoach miles and anticipates that it will do 10,000,000 miles in 1929. It carried 5,500,000 passengers last year and expects to carry 6,500,000 this year. The motorcoaches, one type of which is shown in Fig. 6, operated 96 per cent on time in 1928, and the cost of operation was 29.3 cents per coach-mile. Fifty motorcoaches are operating between Boston and New York City, a 240-mile run, carrying 500 to 600 passengers per day. On the 40-mile run between Boston and Providence, R. I., this company's motorcoaches carry 900 passengers per day.

Another large railroad serving the New England section of the United States, the Boston & Maine, has extensive motor-transport operations. Its subsidiary, the Boston & Main Transportation Co., in addition to its motor-truck services, operates 111 motorcoaches (See Fig. 7) and, by the substitution of them for unprofitable trains, estimates the savings of the railroad at $500,000 per year.

The Boston & Maine Railroad has followed a formula or plan of substitution of highway for rail transportation, which is summarized as follows:

(1) Complete substitution of motorcoach for steam-train branch-line passenger service
(2) Partial substitution on branch lines
(3) Partial substitution on main lines
(4) Complete substitution for electric railways owned by the Boston & Maine Railroad
(5) Complete substitution for electric railways not owned by it
(6) Motorcoach operation to supplement steam-railroad passenger service.

This grouping is based on the relation of the motorcoach to rail passenger-service.

Intercity Motorcoach Service

This class of motorcoach operation may be divided into two parts: the short-haul and the long-haul. In the case of some of our strongest lines, the long haul has become a transcontinental operation. According to the most reliable figures available, interstate motorcoach lines sold 1,450,000,000 passenger-miles and carried 29,000,000 passengers in the year 1928. An official of one of the transcontinental lines operating out of New York City stated recently that between Sept. 11 and Oct. 16, 1928, the average ticket sale was for a distance of approximately 1100 miles.

Consolidation of the operations of the Greyhound Lines and the Yelloway Stages has resulted in the longest, largest and most dependable motorcoach system in America. In a 36-page time-table folder, this system lists 110 different routes between the principal cities of the United States, from coast to coast, from the

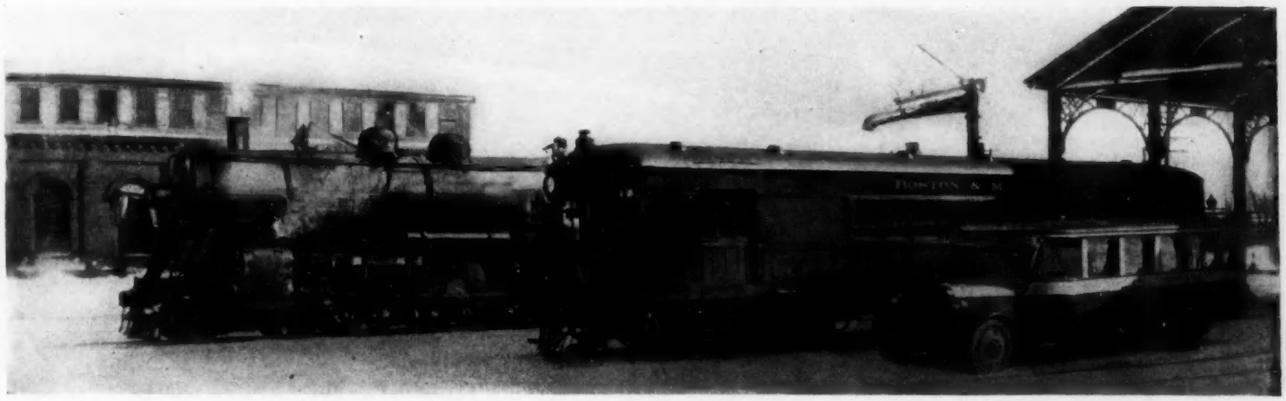


FIG. 7—COORDINATION OF RAIL AND HIGHWAY TRANSPORTATION BY THE BOSTON & MAINE RAILROAD

Steam and Electric Railway and Motorcoach Service Are Rendered by This Railroad Company, the Three Forms of Transportation Operating from the Same Stations

Great Lakes to the Gulf of Mexico, and from the Canadian to the Mexican border. Moreover, quite recently this operation has become allied with several of the largest railroad systems of the Country and it is safe to predict that it is only the beginning of the most comprehensive system of coordinated rail and road transport facilities in the world.

Long-distance motorcoach transportation has grown amazingly during the last 18 months and rapid progress is daily being made in this field. Two things that are accelerating the development and stabilization of the long-haul lines are mergers of weak with strong companies and the renewed efforts by railroad executives to coordinate their rail services with the motorcoach services of those and other companies in their respective territories.

TABLE 2—COMPARISON OF LONG-DISTANCE SERVICES BY MOTORCOACH AND RAILROAD

	Distance, Miles		Running Time, Hours			Fare			
	Motorcoach	Rail	Motorcoach	Rail	Saving by Rail	Motorcoach	Rail	Saving by Motorcoach	Per Cent Saved by Motorcoach[a]
Atlantic City, N. J.	136	129	6	3½	2½	$3.75	$4.93	$1.18	24.8
Baltimore	200	187	9½	4	5½	4.50	6.70	2.20	32.7
Cleveland	557	579	24	17½	6½	13.00	20.55	7.55	36.7
Cincinnati	717	751	29	21½	7½	17.50	27.01	9.51	35.2
Denver	1,988	1,943	76	54½	21½	40.75	69.68	28.93	41.5
Los Angeles	3,391	3,111	134	92	42	70.25	109.77	39.52	36.0
Memphis, Tenn.	1,314	1,158	51	33	18	29.00	41.71	12.71	30.4
Rochester, N. Y.	375	370	15½	9	6½	10.00	13.35	3.35	25.1
St. Louis	1,009	1,053	40	27	13	23.50	38.06	14.56	38.2
San Francisco	3,404	3,180	133	92	41	73.75	109.77	36.02	33.7

[a] Average percentage of saving by motorcoach over rail, 32.8.

Table 2 gives a comparison of railroad with long-distance motorcoach transportation between New York City and some of the other principal cities in the United States as to distance, time and rates of fare, and is very illuminating as an indication of what the motorcoach offers as to time and cost as a competitor of the older form of travel.

A Motorcoach for Night Travel

The long-distance motorcoach operator of today is fulfilling more and more the public demand for extensive and better transportation service. With a comprehensive system of good roads and the common urge of the public to "ride on rubber," long-distance motorcoach transportation assures the public a dependable means of travel. As an illustration of new ideas, we now have the Nite Coach, shown in Fig. 8, a Pullman-type vehicle that provides sleeping quarters for 26 passengers in 13 compartments. It also has dining service, lavatories, smoking and baggage compartments and other unusual features. By an ingenious arrangement, the upper and lower compartments are made to interlock, reducing the height of the vehicle to within a few inches of that of the customary motorcoach. Heavy curtains give privacy to each compartment at night and, when they are drawn aside, the compartment becomes a small stateroom having two deep-cushioned chairs facing each other and a wide three-panel window extending the full length of the compartment. Each compartment is provided with a thermos jug of ice water, a wash basin with running water, and two drawers for clothing and other personal effects. All the necessary equipment, such as mattresses, sheets, blankets and pillows, is carried in the vehicle. Each berth is 6 ft. 4 in. long, and the interlocking feature provides a private drawing-room for each person directly adjoining. In the front of the vehicle is a kitchen in which a steward can prepare hot food, which is served to the passengers in their compartments. At the rear is located a lavatory complete in every way. Chemical tanks take care of all waste until division points are reached.

The crew of this motorcoach consists of a driver, a steward and a porter. The construction is completely different from that of the conventional motorcoach, as it has no chassis in the usual sense, the frame and body being riveted together as a unit. By the liberal use of duralumin, the weight of the vehicle, unladen, is held down to approximately 14,000 lb. Everything possible is being done to make the service attractive. Tickets give the traveler the right to change at night and travel by train, or he can engage a seat in an air-

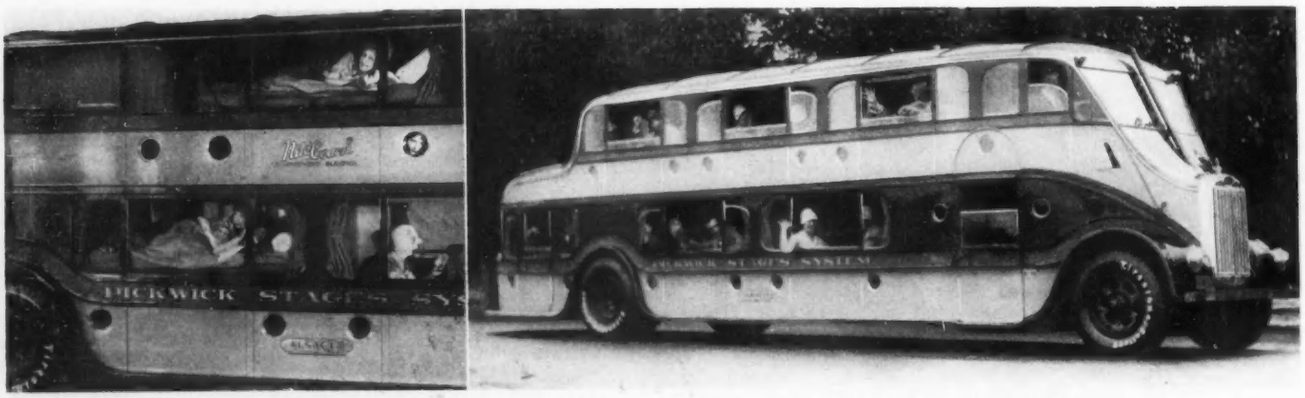


FIG. 8—UNIQUE MOTORCOACH SPECIALLY DESIGNED FOR LONG-DISTANCE TRANSPORTATION

This Low Double-Deck "Nite-Coach" Is Provided with Sleeping Berths, Arrangements for Cooking and Serving Meals, and More Conveniences and Passengers than Are Provided in Modern Pullman Sleeping Cars. The Seating Arrangement Accommodates 26 Passengers. By the Liberal Use of Aluminum, the Weight of the Vehicle, Unladen, Is Held Down to 14,000 Lb.

TABLE 3—ANALYSIS OF POPULATION IN 1032 CITIES OF THE UNITED STATES HAVING A POPULATION OF MORE THAN 10,000 PERSONS IN 1928

Group by Population	Number of Cities	Per Cent of Cities by Groups	Increase in Number of Cities over 1920, Per Cent	Aggregate Population	Per Cent of Total Population of Country	Increase of Population over 1920, Per Cent
More than 1,000,000	6	0.58	100.00	15,046,034	12.54	48.31
250,000 to 1,000,000	26	2.52	8.34	11,706,730	9.76	4.15
100,000 to 250,000	58	5.61	41.80	8,769,073	7.31	45.00
50,000 to 100,000	97	9.30	27.80	6,680,083	5.57	26.63
25,000 to 50,000	225	21.80	56.20	7,914,481	6.59	55.37
15,000 to 25,000	286	27.70	40.90	5,425,426	4.52	39.53
10,000 to 15,000	334	32.40	24.00	4,010,529	3.34	24.14
Total	1,032	100.00	36.00	59,553,228	49.63	32.61

plane at one of the several airports on the route and continue his journey by air transport. This enables the passengers to ride by motorcoach during the day to view the scenery, to travel in the sleeping compartment of a railroad train at night, and resume travel by highway in another motorcoach at a different transfer point the next day.

Development of City Motorcoach Service

While transcontinental and long-haul lines have been making spectacular gains in all parts of the Country, the city and suburban type of motorcoach transportation has been making steady progress in developing city services. Hardly a city transportation company exists today that does not make use of the motorcoach which, when adopted as a vehicle for regular city passenger transportation, presents some marked advantages. It loads at the curb, thus avoiding discomfort and injury to passengers, who are compelled to go to the middle of the street to board the street-car. It avoids the necessity of fixed routes and heavy investments in track and power equipment. It permits the operation of flexible and easily changed schedules that better meet the legitimate needs and even the whims of the riding public.

One of the most important essentials concerning the problem of transportation is to recognize that the automobile has revolutionized travel methods and has an appeal to personal convenience. Furthermore, the advantages and limitations of the street-car and motorcoach, and their effect upon the riding habit, must be recognized. Let us see what some of our cities have done with transportation during the past year. In one city where the transportation company was operating street-cars and changing over to motorcoaches, an increase in mileage from 464,000 in 1926 to 471,000 in 1927 was made by the motorcoaches. These were operated at a cost of 16¾ cents per mile, saving the company more than $33,000 in one year. Another city, in the northeastern part of the United States, was faced with a serious transportation problem, as street-car patronage was constantly declining and the rolling-stock was in bad condition. A reorganization was made and motorcoaches were substituted for the street-cars. Since that time the operating expenses have decreased 27 per cent, the net income has increased 267 per cent, and the investment decreased 70 per cent. During 1925 the average street-car monthly net operating income in that city was $941.31; during 1927 the motorcoach net operating income for one month was $2,520.82. In the City of Washington, an electric-railway company found that, after experimenting with motorcoaches and coordinating them with street-car service on certain routes, the car and motorcoach mileage increased over 171 per cent in the first six months on an operating cost of less than 23 cents per mile, and with an increase in revenue of more than 33 1/3 per cent.

City-wide motorcoach transportation is at present most marked in the smaller cities. For example, in 120 or 19.4 per cent of the cities under 25,000 population, motorcoaches serve the riders exclusively; 25.1 per cent of the cities of 15,000 to 25,000 population are thus served; and of the cities of 10,000 to 15,000 the percentage is 14.1.

To appreciate the significance of these figures, two other factors should be considered; one is the migrating tendency of the rural population toward the cities, and the other is the increasing tendency toward individual transporation, as shown in Tables 3 and 4.

From a transportation point of view, these tendencies mean changed conditions. New parts of cities have been built up and additional demands have been created for local transportation service. In many cases these demands have been satisfied by the operation of motorcoaches, either as feeders to existing street-car lines or on entirely new routes which have been established exclusively with motorcoaches. This is shown by the fact that in all cities of more than 250,000 population motorcoaches are now being used to supplement the other transportation facilities. In approximately 81.3 per cent of the cities having between 50,000 and 250,000 population, in addition to other transportation facilities, motorcoaches are used for the most part in local service.

On the other hand, the rapid growth in the use of the private automobile has changed traffic demands in the smaller cities, especially those of less than 50,000 population. Table 4 shows that

TABLE 4—ANALYSIS OF LOCAL MOTORCOACH SERVICE IN CITIES HAVING MORE THAN 10,000 POPULATION

Group	Cities in Group	Local Motorcoach Service: Number of Cities	Local Motorcoach Service: Per Cent of Total	All Transportation by Local Motorcoaches: Number of Cities	All Transportation by Local Motorcoaches: Per Cent of Total	Per Cent of Cities Having Motorcoach Service
More than 1,000,000	6	6	100.00	0	0	0
250,000 to 1,000,000	26	26	100.00	0	0	0
100,000 to 250,000	58	50	86.21	1	1.75	2.00
50,000 to 100,000	97	76	78.35	2	2.06	2.63
25,000 to 50,000	225	140	62.22	30	13.40	21.42
15,000 to 25,000	286	133	46.50	72	25.10	54.21
10,000 to 15,000	334	95	28.47	48	14.10	50.62
Total	1,032	526	50.97	153	14.80	29.08

there are now 845 such cities. It is largely in this group that the local motorcoach is making history today; and, as successful operation is demonstrated in these, a wider use of motorcoach in the next larger group, from 50,000 to 100,000, will be brought about. In fact, today 78 per cent of these cities have local motorcoach service. Preliminary figures indicate that 12,000 motorcoaches are used in these local services and that the volume of traffic now being handled amounts annually to 1,505,000,000 passengers.

Motor-Omnibus Operation in London

As England is the birthplace of the municipal motor-omnibus, relatively little time elapsed after the perfection of the first motor-vehicle before the internal-combustion engine was applied to public-transport-service vehicles operating in the streets of London. As early as 1904 the first motor-omnibus was licensed by Scotland Yard. This was owned by the London General Omnibus Co. Horse-drawn, electric and steam-driven buses were from that date rapidly supplanted by the new motor-driven type, and the development immediately spread to other large cities in the British Isles.

The London General Omnibus Co. service is now one of the largest city motor-transport operations in the world. During 1927 the total number of passengers carried was 1,323,423,000, an increase of 74,000,000 over the previous year. The average number of passengers carried daily is 3,909,000. This company now owns 3990 motor-omnibuses and operates a total of 4887 covering 880 route-miles. Revenue last year amounted to $43,546,000, an increase of more than $800,000 above the previous year; while expenditures were $40,061,000, an increase of $350,000 over the year before. Net receipts last year were $2,225,000, compared with $1,863,500 for 1927. During 1928 this company absorbed a number of independent competing companies, which is partly responsible for the increase in equipment and mileage operated. Except for a limited number of suburban routes, double-deck vehicles are used exclusively in London, the seating capacity ranging from 36 to 54.

School Children Transported by Motorcoach

The school motorcoach has done much to bring quick and comfortable transportation to the school children and ease of mind to parents and educational authorities throughout the whole of the United States. We now have in service more than 40,000 such vehicles, an increase of 5000 over the year 1927. The route miles increased in the year from 352,892 to 410,527. The average route slightly exceeds 10 miles. From even this brief description of our school-omnibus development, it can readily be seen what an important service is being rendered in this field of transportation.

Motor-Vehicle Operating Problems

Four major factors are involved in all motor-transport operations. These are the load, the haul, the loading and the unloading. As in all other business activities, we must know our costs if we are to succeed. The subject of motor-vehicle operating costs is complex and many papers could be devoted to it. Therefore I can only touch on it here.

Records, particularly cost records, are not the cure for operating ills, but are merely the instrument that shows us the facts. A doctor uses his clinical thermometer to learn whether a patient has fever; then it is his skill in determining the cause and knowing the proper treatment that effects a cure, not the thermometer. We must first of all keep full and accurate cost records, then know how to analyze them and act accordingly (See Figs. 9 and 10).

The basic principles of motor-vehicle operating costs can best be classified under two general headings:

(1) Variable Operating Expense, and
(2) Fixed Operating Expense.

Under Variable Operating Expense should be included:

(1) Gasoline or electric energy
(2) Oil
(3) Tires and tire repairs
(4) Repair material used on chassis
(5) Repair material used on cab, body, or auxiliary equipment
(6) Repair labor used on chassis
(7) Repair labor used on cab, body, or auxiliary equipment
(8) Painting labor and material
(9) Accident labor and material
(10) Garage labor
(11) Garage material
(12) Miscellaneous expense

Under Fixed Operating Expense should be included:

(13) Drivers' and helpers' wages
(14) Garage rent and maintenance
(15) Insurance for vehicles
(16) Licenses and taxes on vehicles
(17) Depreciation on vehicles
(18) Superintendence
(19) Interest on investment in vehicles
(20) Overhead; garage, shop and stores
(21) Administrative expense

Record forms required in keeping these costs vary

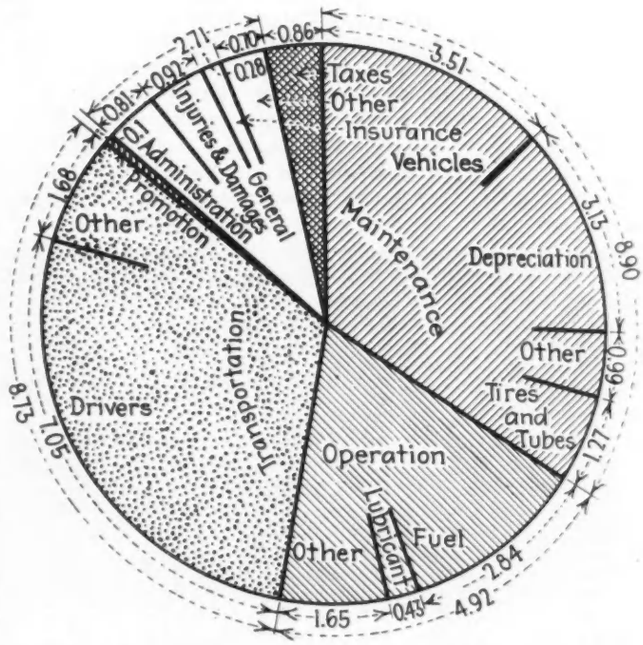


FIG. 9—MAIN OPERATING COSTS OF 92 CITY MOTORCOACH COMPANIES

The Average Total Expense Is 26.22 Cents per Coach-Mile

to some extent depending on the nature of the operation. Those listed below are recommended:

(1) Driver's Daily Time-Card
(2) Tire-Change Report
(3) Daily Time-Card
(4) Material Requisition
(5) Repair-Shop Job-Order
(6) Daily Gasoline and Oil Report
(7) Tire Record
(8) Stock Record-Card

As the driver's daily reports are the basis for most of the data from which the costs are derived, it is vitally important to have them filled out correctly and promptly. Records that, even to a small extent, are filled out from memory can never be correct in every detail.

A very wide divergence of opinion exists in the ranks of motor-transport operators, transportation engineers, and cost accountants, regarding the whole subject of motor-vehicle cost accounting. For example, the item of depreciation is highly controversial. Some insist that it be kept on a mileage basis, while others are equally emphatic that the only correct system is on the annual basis. As obsolescence is frequently a controlling factor in estimating the life of a motor-truck or motorcoach, I have always held that, for general use, the mileage basis is the right one. In the classification given here I have, for particular reasons, included depreciation under fixed expense.

It should always be borne in mind that correct accounting of motor-vehicle expense is necessary to proper control of motor-vehicle operation.

Examples of Economics of City Service

A few clearly defined examples of the economics of city-service motorcoach operation follow.

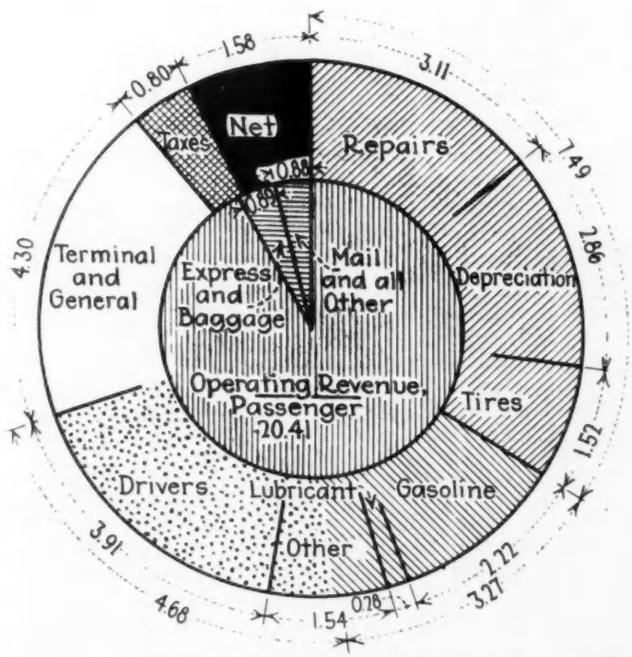


FIG. 10—OPERATING EXPENSES AND REVENUE OF INTERCITY MOTORCOACHES DURING 1926

The Average Total Revenue Was 22.18 Cents per Coach-Mile

Denver.—In the Rocky Mountain region of the United States, motorcoaches were substituted for the electric-railway car. In 1925 the Denver & Interurban Co., a subsidiary of the Chicago, Burlington & Quincy Railroad, placed four motorcoaches in operation, and in 1926 electric-car service, which years ago had replaced steam trains, was discontinued entirely. The cost of operating these motorcoaches and the revenue derived from them for one year were as follows:

	For the Year 1927
Total Gross Revenue	$142,444.81
Total Operating Expenses	119,677.13
General and Miscellaneous	18,736.60
Taxes	5,543.38
Other Deductions	4,251.37
Non-Operating Income	439.07
Net Revenue	13,412.00
Maintenance of Equipment	Cost per Mile, Cents
Maintenance, less depreciation and tires	2.51
Depreciation	4.00
Total	6.51
Transportation	
Drivers	4.50
Gasoline	3.00
Oil and Grease	0.43
Tires and Tubes	1.66
Insurance and Damage	1.44
Other Transportation Expense	3.89
Total	14.92
Traffic	0.57
General and Miscellaneous	
General Officers and Office Supplies	1.89
Legal and Other Expense	0.46
Total	2.35
GRAND TOTAL	24.35

City of Washington.—The Capital Traction Co. operates 13 29-passenger parlor coaches in de luxe suburban service between Chevy Chase Circle, Md., and the Union Station and the Capitol. The length of route is 8 miles; the running time, 34 min.; the schedule speed, 14.5 m.p.h.; and the fare, 25 cents.

TRAFFIC

Year	Passengers Carried	Miles Operated
1925	71,466	98,022
1926	308,803	353,021
1927	388,803	395,373
1928	441,653	447,056

OPERATING COST
1928

Operation	Cost per Mile, Cents
Drivers	5.70
Gasoline	2.65
Lubricants	0.39
Other Transportation Expense	0.29
Total Operation	9.03
Maintenance	
Bodies and Chassis	2.41
Building and Grounds	0.03
Service Car	0.02
Garage Employes	1.24
Tires and Tubes	1.03
Shop and Garage Equipment	0.01
Shop and Garage Expense	0.37
Depreciation	5.08
Total Maintenance	10.19
Total Transportation	19.22

Fixed Charges	
Administrative Salaries	0.26
Traffic Promotion	0.04
Injuries and Damage	0.59
Miscellaneous General Expense	0.12
Total General Expense	1.01
Total Operating Expense	20.23
Taxes	0.75
TOTAL EXPENSE	20.98

These motorcoaches operate over the same routes as the Washington Electric Railway street-cars and have increased the revenue more than 35 per cent., with a mileage increase for both motorcoach and street-car of more than 171 per cent.

Danbury, Conn.—Another good example of a small community in which motorcoaches have been used effectively is Danbury, a factory city of 30,000 population. The traction company was on the verge of bankruptcy and motorcoaches were substituted, with results as follows:

	Cost per Mile, Cents
Drivers	5.72
Gas and Oil	2.80
Garage Labor and Expense	1.77
Superintendence and Miscellaneous	0.85
Total Transportation	11.14
Maintenance of Buildings and Equipment	2.64
Depreciation	2.00
Total Maintenance	4.64
General Officers and Office Supplies	2.09
Insurance and Damages	2.44
Legal and Other Expenses	.42
Total General	4.95
GRAND TOTAL	20.73

Repair and Maintenance

The old adage "A stitch in time saves nine" is an excellent motto to adopt in the repair and maintenance of motor-transport equipment. Fifty dollars spent in a thorough and frequent inspection will save five times that sum in repairs after the damage is done. A commercial motor-vehicle in the shop not only costs money to repair but is losing the operator money each day it is out of service, and frequently may be the direct cause of losing a customer because his hauling has been delayed and he seeks a more reliable agency to perform his transportation.

One of the big questions to decide in motor-transport operation is whether to rely on the vehicle manufacturer's service station for repairs or to have the work done in the operator's own garage or shop. For the small-fleet operator the service station is more satisfactory for major repairs and complete overhauls. The large-fleet operator usually can save money and time by maintaining his own repair-shop and carrying a stock of essential parts.

Road Failures a Gage of Efficiency

The efficiency of an operation undoubtedly should be gaged by some definite unit of measurement. From the experience of many operators the involuntary-stop factor is a fairly good gage of the efficiency of an operation as regards reliability of service and equipment performance. These involuntary stops or road failures give a fairly accurate picture of maintenance efficiency when properly classified to indicate whether the vehicle, the driver, the road or weather conditions are to blame. As a basis of measurement, it is usual to class as involuntary stops all road delays of about 10-min. duration or more. Using this basis, one company during one month averaged 5700 miles in city service and 13,500 miles in intercity service for each equipment failure. In this particular case, equipment was responsible for about two-thirds of all delays on the city routes. Bad roads, traffic congestion, and waiting for connections were the main causes of delay on the intercity runs, while equipment was charged with only about 9 per cent of the total. Accidents played but a small part in causing delays in both city and intercity operations.

The involuntary-stop efficiency of an operation can be determined in a number of ways. The following important items, covered in each case by a form designed for the purpose, must be considered:

Form No. 1.—Service calls. Institution of this form at once assists in reducing the number of daily service calls.

Forms Nos. 2 *and* 3.—Trouble call and repairs to be made in the shop are made out in one operation on a 5 x 7-in. form. The original of this report is made on salmon-colored paper and filled in by the road mechanic, who gives details as to the driver's cooperation in a mechanical way. The duplicate, a yellow slip headed Shop Order Following Trouble Call, is used by the foreman in authorizing garage repairs to the motorcoach involved.

Form No. 4.—Delays and nature of trouble may be kept by route. A daily report on the letter-size 8½ x 11-in. white-paper form is made out by the dispatcher.

Form No. 5.—A special colored card indicates delay. On this the driver tells the transportation part of the story. Printed on green stock 3 4/5 x 8 in. in size.

Form No. 6.—A combination form, the driver reporting the number of passengers carried, oil and fuel consumption, as well as delays on each trip. Printed on white bond paper, 5½ x 8 in.

Form No. 7.—Comparative trouble-calls report. Printed on thin white paper, 5½ x 8 in. in size, sent to all executives as well as to department heads in charge of transportation and maintenance.

A very good picture of the causes of delays on a typical city operation is shown on the accompanying chart, the summary of which gives some ideas as to how troubles vary with vehicles of different capacities. Irrespective of how delays are counted, some classification must be made in the report, and the following is giving very satisfactory results:

(1) Traffic; caused by bad roads, heavy traffic on road or vehicles, inclement weather
(2) Involuntary; due to vehicle failures, as tires, electrical, mechanical or any other part
(3) Accident; caused by accidents in which the motorcoach itself is involved.

Also, further suggestion is made that a fourth classification, based on the time a unit is out of service and in the shop, be added to the foregoing. This is particularly useful in checking up the out-of-service time for a unit in the event that it must be brought in for adjustments or repairs other than when ordered in for regular inspection, this time to be charged the same as if a road delay had occurred.

Various methods of procedure are followed by the companies using this system. One company merely re-

quires a report of time lost on each trip, with an explanation of the reason. Another secures the basic data from both the transportation and the maintenance departments as reported by the driver and the road inspector. In general, the system is satisfactory, as it gives two sides of the story of the trouble and also shows the time taken to remedy it.

This is a rather new subject to some transport operations, although the London General Omnibus Co. has for years used the involuntary stop as a yardstick by which to measure the quality of its service and operating efficiency. The fact that it is such a simple way to arrive at the cause of the main troubles encountered in the operation of freight and passenger-carrying motor-transport vehicles will, I am convinced, bring the system into universal use. To successfully operate motor-transport facilities, we must know the facts promptly.

Street-Traffic-Congestion Control Methods

According to the report of the Plan of New York an Environs, made up of an impartial and non-political body of experts, traffic congestion such as that shown in Fig. 11 is costing the New York City metropolitan region $1,000,000, and the Chicago loop district, only, $200,000 per day. Other thickly populated centers are paying in like proportion.

Some of the solutions proposed are restricted parking of vehicles between certain hours, widening of arterial thoroughfares, and a more intensive use of all forms of vehicular traffic. The horse-drawn vehicle, in general, seriously delays the flow of traffic, particularly in winter when the streets are covered with snow and ice. Adoption of night delivery by truck of certain bulk commodities such as coal, building materials and selected classes of heavy merchandise is becoming a more and more important move to relieve traffic congestion in our large cities. This subject has recently been brought into considerable prominence by the police commissioner of New York City, Grover Whalen, who, it is believed, may, through police powers, force a trial of such a plan. He has called upon the merchants, truckmen and other interested parties for recommendations and advice to aid him to develop a plan, if possible, that will least interfere with established customs and demands. Such an arrangement, properly handled and well supported, is certainly worthy of a fair trial, and, if tied in with a practical store-door-delivery service, should bring real relief to the traffic-congested centers. At the same time, it should be provided that ordinary repairs to streets, gas and water mains, sewers and other facilities requiring closing or restricted use of the streets must, as far as possible, be made at night.

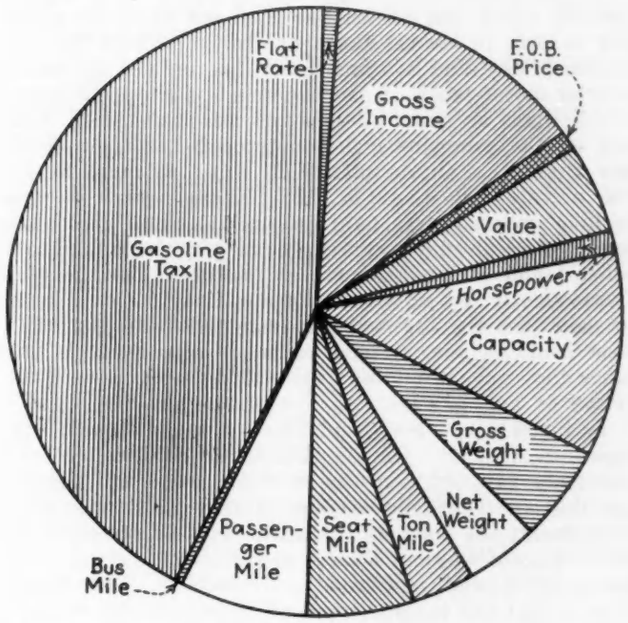


FIG. 12—BASES OF MOTORCOACH TAXATION IN THE UNITED STATES

The Chart Is Based on Percentage of the Average Taxation of $524 per Vehicle in 1928 and Shows the Various Factors on Which Motorcoaches Are Taxed in the Several States. The Tendency Seems To Be Toward Taxation on Gasoline Consumption and Gross Operating Income

FIG. 11—TRAFFIC CONGESTION AT THE PIERS ON WEST STREET IN LOWER NEW YORK CITY

Considerable progress has been made during the last year or so in attacking this problem, largely, it is true, from a theoretical standpoint such as the making of surveys and the submitting of all kinds of remedies by engineers, architects and others. Many of the proposed remedies seem radical to the layman and some even to the expert, but all have a certain amount of merit and so, perhaps, are worthy of consideration. Soon we shall be experimenting with parts of the more practical of these plans and ultimately, by the process of evolution in general and revolution where occasion demands, we shall bring order in some form out of the existing costly chaos that is the daily portion of every man, woman and child. Will Rogers, our fa-

mous humorist, says, "Everyone in America spends one-half of his or her time waiting for the traffic light to change."

High Taxation of Commercial Vehicles

In the United States motor-truck users not only pay for the use of the roads, but they pay twice as much per vehicle in special taxes as the owners of private automobiles. The average State tax on the common-carrier motor-truck of average size is $303 per annum, or 15 times as much as on a private automobile. The tax on the common-carrier motorcoach averages $520 per annum, or approximately 24 times as much as on the private car (See Fig. 12). These figures do not include general taxes paid on public and private garages, gasoline filling stations, repair shops and all other levies which are paid by motor-vehicle owners. Consequently, by no stretch of the imagination can it be said that the highway program depends upon railroad contributions or that railroads are, through the taxes they pay, providing free roadbeds for their competitors.

Two points of view are held in connection with the question of taxes. One is that motor-vehicles do not pay their fair share of the cost of road maintenance and that the railroads, because of their large property investment, pay not only the maintenance costs of their own rights-of-way but a large share of the cost of road maintenance and new road construction. The other view is that the various types of motor-vehicles do pay fair taxes in the forms of license fees, gasoline taxes, personal-property taxes, and so forth, and have, through their presence, largely increased the value of property in the sections served.

It is also contended that, because of the demand for the motor-vehicle, road-construction programs have been large, which further increased the sale of automobiles, with a corresponding increase in the movement over the railroads of road material, raw material for automobile manufacturing and finally the finished product, and that these large increases in traffic have more than compensated the railroads for the proportion of the taxes paid by them for road construction and maintenance. This proportion amounted to 2.4 per cent of the total 1928 highway bill of $1,465,000,000, or $35,507,840.

Sound Principles of Special Taxation

The following sound and equitable principles to control special taxation for motor-vehicles have been annunciated by the National Automobile Chamber of Commerce:

(1) The State should be the sole special taxing agency. Federal, county and municipal governments should be excluded from the field.

(2) The motor-vehicle tax should be simple in form and distributed in equitable and just proportion between the different types of motor-vehicle.

(3) No highway should be improved by expenditure of public funds in excess of its earning capacity. The return to the public in the form of economic transportation is the sole measure of the justification for the degree of improvement.

(4) All money raised by such special taxes should be placed in the State Motor-Vehicle Highway Fund, and to secure the best results should be expended under the direction of the State Highway Department.

(5) The cost of building and maintaining adequate systems of highways should be distributed in an equitable relation to the benefits derived. These may be summarized as follows:

(*a*) Benefits to society in general, such as influence on education, recreation, health, fire prevention, police protection, the national defense, the postal service, living and distribution costs

(*b*) Benefits to definite groups such as agriculture, manufacture, labor, railroads, mining, forestry and waterways

(*c*) Benefits to property served

(*d*) Benefits to the road user.

(6) For the purpose of apportioning costs in relation to benefits received, all highways may be divided into two classes; first, those used by the general motoring public, and, second, those which perform a purely local service function.

(7) Special motor-vehicle taxes should be levied and used only for the improvement and maintenance of highways used by the general public; that is, for general highway-traffic flowlines.

(8) The wide variance in valuations, tax burdens, number of motor-vehicles in use and the status of highway development in the several States prevents the adoption of any fixed formula as to the proportion of the total costs of highways of general use which should be paid for from motor-vehicle funds. Generally speaking, however, these principles may be set forth:

(*a*) In States where the income from motor-vehicles is insufficient to meet all of the maintenance costs of highways of general motor use, without undue burden to the individual motorist, such funds should be applied first to the maintenance of interstate and State highway systems.

(*b*) In States where the income from motor-vehicles is sufficient to meet all maintenance costs of highways of general motor-transport use without undue burden to the individual motorist, any surplus should be used for this class of highway reconstruction and administration costs.

(*c*) In States where the number of motor-vehicles will bring in large sums in excess of maintenance without placing undue burden upon the individual motorist, such surplus should be used to defray all costs of maintenance and a substantial share of all of the other costs of highways of general motor use.

(*d*) In those States where the motor-vehicle income is more than sufficient to meet maintenance costs of highways of general motor use without undue burden to the individual motorist, it may be found advisable to use such surplus for the purpose of defraying all or part of the costs of bond issues to expedite the construction of economically desirable motor highways.

(9) Roads of a purely local interest, serving only local needs, should be financed out of local rev-

enues obtained from local general taxes. Special assessments on adjoining land to defray a portion of the cost of such roads may be justified.

(10) Where extraordinary improvements are undertaken in the vicinity of, or serving, congested areas of population, the increment, if any, in property valuation following the improvement should be drawn upon to defray an equitable portion of the cost.

(11) Irrespective of the particular form of special tax of the motor-vehicle, whether registration fees of motor-fuel taxes, the aggregate amount of these taxes in any one year should not be so great as to impose an undue burden on the individual motorist.

Regulation of Motor-Transportation Lines

Investigations show that there is no uniformity in rates charged by various motor-truck and motorcoach lines. Many are selling transportation service at rates so low as to seriously jeopardize the revenue, not only of the railroads, but of the well-organized and well-operated truck and motorcoach lines. In a recent article entitled, Problems of Highway Transport Regulation, Alfred H. Swayne, vice-president of the National Automobile Chamber of Commerce, shows that a public demand for motor-truck regulation has not yet developed. On the other hand, a very definite demand exists for the regulation of motorcoaches.

Regarding motor-vehicle regulations, Thomas H. MacDonald, chief of the Bureau of Public Roads of the United States Department of Agriculture, says:

> Regulation of all public transportation agencies in the interest of the public is necessary and sound, but we have been thinking and acting in terms of restrictive regulation and, to do so, it is necessary to evaluate all the factors. From the public viewpoint it will be accepted that each type of service must be permitted to develop in the field in which it can best function. Thus, it is fully as probable that the railroads are over-regulated, in a restrictive sense, as it is that other forms of transportation are under-regulated. The facts ought to be developed.

Regulation of motor transport should be brought about through evolution, not revolution; and under no circumstances should the character of such regulation be dictated by interests antagonistic to the new transportation facility; namely, its chief competitors, the steam and electric railroads.

Restrictions for Road Protection and Safety

Certain restrictions are imposed upon motor-vehicles as to size, weight and speed, in behalf of the safety and convenience of vehicular and pedestrian movement on the highway, and to prevent abuse and unjustifiable wear and tear of highways. The Motor Vehicle Conference Committee of the National Automobile Chamber of Commerce clearly states the problem of proper police regulations thus:

(*a*) Shall the dimensions, weights and speeds of motor-vehicles and their loads be reduced to capacities of the weakest highways of parts thereof, or

(*b*) Shall all highways and parts thereof be lifted up to standards of improvement adequate to carry the biggest, heaviest and swiftest loads that users of motor-vehicles desire to place upon them?

The Committee believes that between these two extremes lies a compromise which motor-vehicle manufacturers, in designing their vehicles; highway engineers, in building their roads and bridges; and public authorities, in maintaining and regulating traffic upon them, could follow. Recommendations of this Committee, in part, are:

SIZE OF VEHICLE

(1) Width, including load, 96 in.; traction engines, 108 in.

(2) Height, including load, 14 ft. 6 in.

(3) Length, including load: (*a*) single vehicle, 33 ft.; (*b*) combination of vehicles, 85 ft.

Note.—From the foregoing it is apparent that, to admit of the safe passage of two vehicles each of which with its load is 96 in. wide, a highway at least 20 ft. in width is desirable.

GROSS WEIGHT

(1) Single vehicular unit of four wheels or less (tractor, semi-trailer or trailer to be regarded as separate unit), 28,000 lb.

(2) Any one axle of a single vehicular unit of four wheels or less, or any axle of a semi-trailer or trailer, 22,400 lb.

(3) Per inch width of tire measured between flanges of the rim in case of solid rubber tires:

Size of Tire, In.	Load per Inch, Maximum, Lb.	Size of Tire, In.	Load per Inch, Maximum, Lb.
3	400	7	750
3½	400	8	800
4	500	10	800
5	600	12	800
6	700	14	800

(4) Minimum thickness of rubber for solid rubber tires:

Size of Tire, In.	Thickness, In.
3, 3½, 4, 5	⅞
6, 7, 8	1
10, 12, 14	1⅛

SPEED

	Miles per Hour
Upon urban streets	20
Upon suburban streets	25
Upon any other street or highway	40

Note.—The laws of many States prescribe, for the three types of thoroughfare indicated, a graduated schedule of speed limits based on the kind of tire equipment of the vehicle and its gross weight. Such elaborate and detailed schedules, however, are very difficult to enforce.

Except as indicated, the subordinate political subdivisions of the State, such as counties, cities, towns, boroughs and townships, should have absolutely no power to prescribe size, weight or speed restrictions at variance with those prescribed by the State laws. The need for such limitations on local governing bodies is too obvious to require discussion.

Conclusion

In conclusion, let me urge all concerned to study separately each problem involving the movement of both freight and passengers by motor transport; in other words, as a case by itself. Of course, certain basic principles are common to all such problems, but no general formula can be used either in the application or the operation of any form of motor transport. Careful investigation by experts is the first step in approaching any transportation problem and, though apparently an unnecessary expense, will invariably prove to be the cheapest method in the long run.

There is a great dearth of men who understand the scientific application of motor transport to everyday

transportation requirements. This is true even in the United States, where the use of commercial motor-vehicles has reached such a high stage of development. Undoubtedly this is also true in other countries where the tremendous possibilities of this new transportation tool are only beginning to be realized. Every country that desires to progress and attain to a high degree of perfection in these matters should see to it that its schools and colleges have available properly conducted courses of training from which will come yearly men possessing the technical knowledge of transportation that will fit them to intelligently study the practical side of the business. They must know the practical side to succeed in handling motor-transport operations.

The science of the application of motor transport, rather than the design, material and construction of the vehicles, is our biggest problem today. The latter, of course, are highly important but for some years past the design and construction engineer has been taking his cue from the operating man, who, after all, is the one who must make the vehicle perform, and at a profit.

The author desires to express his appreciation to the following organizations for valuable information furnished to him for use in the preparation of this paper and the preceding paper entitled Application of Motor Transport to the Movement of Freight:

Power Wagon, National Automobile Chamber of Commerce, Pennsylvania Railroad, New York Central Railroad, Society of Automotive Engineers, American Railway Express, American Telephone & Telegraph Co., Standard Oil of New Jersey, *Engineering News-Record*, Bus Division of the American Automobile Association, *Commercial Car Journal*, *Bus Transportation*, Pickwick Stages Co., Regional Plan of New York and Its Environs, and *Railway Age*.

THE DISCUSSION

R. E. PLIMPTON[3]:—In his paper Mr. Horner presented a list of seven important uses that the railroads are making of motorcoaches. It seems to me, in view of the experience I have had in the States west of the Mississippi River and what I know of conditions in the East, that there is an eighth important service to which many railroads are putting the motorcoach. That service I might describe as operation on all important highways in the general territory served by the railroads and their branches. It represents an important matter of policy in connection with the steam railroads and I bring it up because Mr. Horner for years has followed the steam-railroad application of motor-vehicles. I know of no man better qualified to tell us whether these railroads, when they go into motorcoach operation, should confine their efforts to the highways parallel to their main lines and branches. They cannot always follow exactly the main lines, but might desire to keep as close to them as possible. Or is it better in their own interests, and in the interest of the public they serve, to operate motorcoaches over all important highways in their general territory?

Railroads Try To Avoid Operating Conflict

F. C. HORNER:—I will go so far as to say that a great many of the railroad officials are thinking along that line, believing that they can legitimately and consistently operate motorcoaches throughout their territory, whether the highways follow their rail lines or not. Without exception, however, they are all against going into another railroad operator's territory, because the other company would undoubtedly retaliate by going into theirs before very long. Right now a considerable number of officials connected with the railroads are confronted with the problem Mr. Plimpton has raised. There is a conflict of territories in certain parts of the Country where two railroads, perhaps three, have claims on the country between certain communities.

In my opinion, the best way to solve a problem of that character would be for them to get together and establish first-class motorcoach service in a joint or combined operation. In many cases they are doing that, but I know of some cases which I cannot mention in which some retaliation is going on because one railroad started a line between *A* and *B* and another serving both *A* and *B* regarded the territory as its own and proceeded to establish competition service between *A* and *B* and also at stations in the other railroad's territory. However, I think that evolution will bring matters to a point where the roads will realize that competition of that character is not beneficial to either the railroads or the public, because sooner or later one of them will suspend operation. The public will be injured to some extent and the railroad will lose good-will.

So I should say, in answering Mr. Plimpton's question, that generally the railroads are doing everything possible to stick to their own territories with their motorcoach and motor-truck lines. However, they do conflict in certain cases, and then it is a matter of negotiation to work out a practical solution.

Cost of Interstate Regulation

MR. PLIMPTON:—Someone told me recently that it would probably cost at least 2 cents a mile for the expenses of interstate regulation if Congress passes such a bill. If that is a fair estimate, would you care to express your opinion as to what economic advantages exist, from the standpoint of the operating company, to offset the added expense?

MR. HORNER:—I am not willing to concede that regulation is going to cost 2 cents a mile. I do not think anyone has any real data to support any figure on the cost to the operator. However, assuming for the moment that it would cost something like that, I should say probably the only thing the operator would have to offset it would be security against anyone setting up a ruinous competition with him. The question is rather new and interesting to me. Where did you get the figure of 2 cents per mile?

MR. PLIMPTON:—It was given to me by a man who has had long experience in steam-railroad operation and also knows the motorcoach business thoroughly through actual experience. He estimates that that is what it will cost if he has to report either directly or indirectly to the Interstate Commerce Commission and go through the proceedings of the sort of hearings that are specified in the proposed legislation.

[3] M.S.A.E.—Associate editor, *Bus Transportation*, Chicago.

CHAIRMAN A. S. MCARTHUR[4]:—It is a very vital subject, particularly to the operators in the United States.

Regulation Cheaper Than Competition

MR. HORNER:—One man here is in a position to discuss it intelligently, because he has sat in at almost all the meetings the Bus Division of the American Automobile Association has had on the subject of interstate regulation. He is Chester G. Moore. I have heard a good deal of discussion on this subject myself. A great many operators and others were much opposed to any further regulation than we already have, particularly interstate regulation, feeling that it would be costly from one standpoint or another, such as delays, legal fees and traveling expenses, but I never heard a figure named until this morning.

CHESTER G. MOORE[5]:—I cannot see any basis for that figure. I think it would probably cost far in excess of 2 cents a mile until such time as the hearings had been completed and the certificates granted, because undoubtedly there would be a great deal of legal expense and other cost in connection with various hearings that would have to be held. But after that, the same as in an intrastate procedure, I believe the cost of interstate regulation would not equal the cost that is now placed upon the operator because of the necessity of his constantly having to combat so-called "wildcat" operation. He is forced to reduce his fares, increase his schedule frequency and do many things that are not in conformity with good operating practice, merely because his competitor is doing them and the public demands them. I think that the cost to him of that sort of thing would exceed any cost there might be of carrying on interstate regulation.

Division of Expense in Cost Keeping

MR. PLIMPTON:—The basic principles of keeping cost records for motor-vehicles, according to the author, "can best be classified" under two general headings; namely, Variable Operating Expenses and Fixed Operating Expense. Let us consider this as it applies to a particular variety of costs: those incurred with say 50 or more trucks used in a business concerned primarily with the sale of tangible goods or commodities. The number 50 is mentioned merely to indicate a large enough fleet to require specialized control by a supervisor responsible not only for routine maintenance but also for accounting and operation.

Under such conditions, is the division into variable and fixed expense the best for all concerned? Take first the "inside" users of the truck service. The sales department, for example, is ordinarily interested in the breakdown of total truck costs into units that can be measured against return from sales. To this and other departments the trucking is merely a service, to be secured from the company's own trucks or from outside haulage companies, as the case may be. Much the same point of view is held by the general executives of the business, who think in terms of total truck costs as applied to material in process or to the finished product. In general, the members of the organization outside the motor-transport department would have little use for the separation of costs on the conventional basis.

Next, it may be asked, Does the laborious compilation of variable and fixed charges give practical assistance to the transportation supervisor and his staff? If a distinction can be made here between cost keeping and cost estimates, the one a current and the other infrequent procedure, the question may be definitely answered. In cost keeping, or the currently compiled records of truck expenses, there is no great advantage in the traditional classification. If total costs, or the total under either heading, Variable or Fixed Expense, are out of line, it means going back to the individual items or accounts; and this could be done just as well with some other group classification.

Even in making estimates, when it may seem convenient to calculate the cost per day, say for a number of different assumed distances, the value of such a hard and fast division of accounts is open to question. Mr. Horner lists as Fixed Operating Expense such items as drivers' wages, insurance, taxation and depreciation. But with many installations these items may more properly, in whole or in part, be considered in the nature of variable expense. Drivers are being paid on a percentage-of-sales basis or according to some bonus scheme, depending upon the vehicle as well as the human performance. The tendency is to put more and more of the accounts in the variable-expense class. Moreover, since the cost estimates are needed only on special occasions, it hardly seems necessary to consider them in preparing the records of day-by-day costs.

One other possible use of the division into fixed and variable charges is as an index of operating efficiency, when the costs are reduced to a mileage basis. A high proportion of variable to fixed charges might indicate good operation, but this information could be obtained more directly and satisfactorily by reports of miles operated per vehicle, or the relation of running time to the time worked by drivers. Here again the separation of the costs into variable and fixed groups does not seem to represent any particular advantage.

Merit of Grouping Under Three Heads

What, then, is a useful method of grouping or division? A few companies have found it desirable to split the costs into three groups according to how the expense is incurred: (*a*) in the garage or shops, (*b*) on the road and (*c*) for general or administrative purposes. Such a division, into maintenance, operating and administrative groups, has the merit of being based upon definite lines of responsibility, so the effectiveness of the personnel can be directly measured. The same principle of division is followed in keeping production, selling and administrative expense separate in a factory organization.

Along with the division here mentioned should come the adoption of other fundamentals. The truck-cost system should be coordinated with the general or financial accounts of the business. Far too many truck accounts are so kept that they cannot be cleared through the general accounts. All truck expense should be distributed or allocated to the manufacturing, sales and other departments served, in accordance with the service each actually receives. The cost system should be so kept as to show the complete truck expense and thus make possible a fair comparison if the purchase of outside truck service is being considered.

[4] A.S.A.E. — General superintendent, Toronto Transportation Commission, Toronto, Ont., Canada.

[5] Eastern representative, Pickwick Nite Coach Corp., Chicago.

Rubber Insulation for Motorboat Engines

By I. W. Robertson[1]

Detroit Motorboat Meeting Paper

THE USE of rubber for insulation purposes and vibration dampening has become almost universally recognized in the motor-vehicle industry. The most notable example of this is as an insulator between the engine-support arm and the chassis to prevent the engine vibrations from being transmitted directly to the body of the car. This development in the motor-car field has not been instantaneous, radical or a fad but has gradually evolved from the execution of a definite program and long experimentation. Insofar as can readily be ascertained, no great amount of work has been done or experience accumulated in the insulation of motorboat engines. However, encouraged by success in automobile-engine insulation, programs and experimentation plans have been laid out recently for extensive developments in the motorboat-engine field. These have not as yet been completed, and for this reason the scope of this paper will be to make suggestions, recommendations, and predictions based on facts acquired from a kindred field, rather than to give a detailed description of development progress which is unfinished.

That an actual need for motorboat-engine insulation exists should precipitate no argument, as it is a common wish expressed by the average user, especially of the outboard type of engine. No argument should arise regarding the ability of rubber insulation to absorb the engine vibrations. The contrast of the luxuriousness of a land vehicle with, and of a water craft without, rubber engine-insulation is evident. The particular underlying principles promoting these improvements in riding-qualities and comfort of automobiles are in the same way applicable to motorboat engines.

Points To Be Considered

Certain fundamental mechanics must be kept in mind when working out designs and applications of rubber insulators for motorboat engines. Most important of these is that the isolation of the engine-support arm from the frame to which the engine is attached must be complete. By this is meant that, for successful results, no direct metallic connections should be made between these two members. Originally, when insulation was effected by curing a slab of rubber separately and then installing it between two metal plates, under compression, this requirement presented some rather knotty problems because of the necessity of a certain amount of engine rigidity. However, the comparatively recent developments wherein an effective bond or union can be obtained between steel plates and rubber, secured by vulcanization under positive pressure, have greatly simplified the problems. On this rubber-vulcanized-to-metal type of engine support the engine arm is attached to one plate, the opposing plate being attached to the base or frame, the rubber between the plates being of such thickness and hardness as to give correct cushioning together with sufficient engine rigidity. With this arrangement, any provision for holding the engine in place other than the adhesion of the rubber to the plates is not necessary. However, various safety designs are being used without interference with the cushioning by the rubber.

Another important fact in the fundamental mechanics of rubber engine-insulation is that the maximum vibration absorption is obtained when the rubber is used under the minimum initial distortion. This means simply that either by compressing or elongating a piece of rubber its resiliency or ability to dissipate vibrations is reduced. The adhesion-type engine-support can be used either in a horizontal or vertical position. If used in the former position, the load is carried under compression; if in the latter, the load is carried in tension and shear. Experience has shown that much better results are obtained when supports are used in the vertical position, owing in part to the fact that when used in this position no initial compression is imposed. Furthermore, a normal characteristic of rubber is that it is more resilient when acted upon in tension than in compression. If this type of insulator is used in the horizontal position, an initial compression at least equal to the maximum permanent distortion of the rubber is necessary or the assembly mountings will in time become loose. The average permanent set of a rubber insulator is approximately 14 per cent of its original thickness. This, however, is dependent upon load and service conditions.

A third important fact to remember in insulator design and service is that the amount of vibration absorption is proportional, within reasonable limitations, to the thickness of the cushioning rubber used. Optimum results, so far, have been secured from insulators in which the rubber was ¼ in. thick on all sides. The shape of the insulator also has a direct bearing upon the area and thickness of the rubber used. In this connection, for best results, the nature and direction of the vibrations or thrusts must first be determined and then the insulator designed and placed so that the rubber will offer least resistance in the directions of the vibrations. Also, within reasonable limits, the nearer to the source of vibration the insulation is placed, the more effective will be the results. Of course, care must be taken not to place the rubber so close to the engine that it will burn or break down prematurely due to excessive heat.

Effects of Hardness, Overheating and Overloading

The fundamental reason for rubber being able to dampen out engine vibrations is that the characteristic vibration-charts of the engine and the rubber are of

(*Concluded on p.* 202)

[1] Firestone Tire & Rubber Co., Akron, Ohio.

Engineering and Service Relationships in the Truck Industry

Discussion of E. D. Sirrine's Transportation Meeting Paper[1]

RELATIONSHIPS that should exist between the engineering and service departments of the motor-truck manufacturing company, and between both these departments and the truck owner, are discussed from the unprejudiced and independent viewpoint of a writer who has had experience in both the engineering and service departments but is some years removed from each.

Being far enough from the trees to see the woods, he presents the responsibilities, obligations and opportunities of the design engineers, service men and even the fleet operator in a light that may be unaccustomed to their restricted vision.

Cooperation, tolerance and a meeting on common ground to discuss mutual problems are urged in the interest of all concerned and of the automotive industry in general.

The engineer can learn much of value from the service man and be of great assistance to him and to the truck owner.

Discussers comment favorably on the excellence of the paper, state that contact by factory engineers with technical operators of vehicles is of utmost value, and tell of interdepartmental cooperation that has been very effective in reducing service complaints. In one large manufacturing organization the cost of satisfying claims for defective design or material is charged to the engineering department, with remarkable results. This places on the design engineer a greater responsibility for satisfactory performance of a vehicle and has brought about a better understanding among the sales, service and engineering departments.

An operation engineer emphasizes the need for the engineer to go into the field, and believes that operation engineers should become better acquainted with the individual delegated for this work, who should be selected for his possession of the proper complex. A plea is made for more recognition of this man and greater consideration for the service man's viewpoint, which is distorted by the constant complaints he hears.

GEORGE P. ANDERSON[2]:—My experience has made me feel deeply appreciative of the completeness and excellence with which Mr. Sirrine has expressed his ideas and I believe that a great deal of good can be derived from it by both manufacturers and operators. He seems to have criticized the men interested in each of the various branches, yet in such a friendly way that no one could take offense but must seriously consider his comments.

In my work on design and later as a transportation engineer, I have found my contacts with the technical operators of vehicles of the utmost value. Mr. Sirrine's paper is one which we would do well to study very carefully.

Steps Taken To Improve Conditions

PIERRE SCHON[3]:—Mr. Sirrine's paper brought back to my mind a number of instances of years ago, in which difficult situations with customers could have been handled to better advantage had a closer understanding existed between the engineering and the service departments.

In our organization, we took steps about two years ago to eliminate one of the sources of misunderstandings that the service and sales departments had to contend with in dealing with designing engineers. The thing which I believe has been a bugbear with many companies is the question, Which account should absorb amounts allowed for settling claims with customers for defective design? The engineering department, as a rule, has felt that its job was completed when a vehicle was designed and released for production, and that it was the duty of the service and sales departments from then on to keep the customer satisfied. If a claim for defective design, material or workmanship was made by a customer, the dealer who sold the truck could not be burdened with the settling of the complaint, and the branch office in the territory, as a rule, was called upon to make settlement with the customer. Under the terms of the manufacturer's warranty, the parts were then returned to the factory for credit, and the service department, as a rule, reimbursed the branch office for the value of the materials. However, the service department did not always feel that its budget would permit it to settle all claims, so the case often came to the sales manager's desk and was charged to a sales-policy account.

In all cases it is essential that settlement with the customer be made immediately, and these remarks refer strictly to the inside working policy of the company in charging claim settlements to a certain account. The sales department certainly is not responsible for a defect in material or design, neither could the service department absorb these charges. To clarify this situation and place the responsibility where it really belongs, claims arising from defective design or material are charged to the department originally responsible for the trouble; namely, the engineering department. That policy has brought remarkable results, as it places on

[1] Published in the S.A.E. JOURNAL for December, 1929, p. 630. The author is connected with the automotive department of the Borden's Farm Products Co., in New York City. The abstract accompanying the paper as published is reprinted herewith, supplemented by a statement of the major points in the discussion as printed herein.

[2] M.S.A.E.—Director of sales engineering, Chrysler Corp., Detroit.

[3] A.S.A.E.—Sales engineer, General Motors Truck Co., Pontiac, Mich.

the shoulders of the designing engineer a greater responsibility for satisfactory performance of a vehicle.

With any kind of product, it may be necessary occasionally to make a campaign change on a certain part, and in such cases it is the policy of our company to call vehicles back into our branch service stations, replacing the defective parts free of charge to the owner. The cumulative amount involved in a campaign change to make corrections in the field is charged against the engineering-department budget. This policy has proved to be a good solution for some of the problems outlined in Mr. Sirrine's paper and has brought about a closer understanding between the sales, the service and the engineering departments.

Plea for Recognition of Service Man

A. W. KENERSON[4]:—I concur 100 per cent in Mr. Sirrine's paper. It comes to me as the reverberation of thunder following lightning, with which I have been very familiar.

I should like to present a reason for the engineer going into the field oftener. We all know that it is very difficult for the engineer to get away from the factory, but all too often the field organization is inclined to believe that the engineers are indifferent as to their problems. The engineer also feels that it is necessary for him to work out his own salvation, which develops a great variety of methods, defeating standardization.

A regular visit to the field by the engineer, or a representative of the engineering department, will go a long way toward inspiring confidence on the part of the field men, and also develop in them a feeling that they do have a Court of Appeal to which they can present constructive criticism and have it accepted as such.

In event that it becomes necessary to send a representative, the one to whom the responsibility of making the field survey is delegated should become very well acquainted with the field organization. He should also be of the proper complex to make it possible for him to listen to a great deal of repetition of the same adverse comment without showing any lack of interest as far as the field man's observations are concerned.

It is highly essential that, when this representative returns to the factory to present his field survey, he in turn be accorded the proper audience. It is also very necessary that minor details be given immediate action, so that this representative, upon returning to the field, can report accordingly to the field personnel; otherwise a feeling that it is useless to report the difficulties will develop.

Furthermore, more consideration should be given the field service-man. This individual is the contact man with the customer and it is his duty to keep the customer satisfied with the equipment he is using. It must be realized that this man receives very few compliments at the best. As he walks through the shop, everything in sight is down and out or it wouldn't be there. His telephone is kept red hot with requests for service, demands for impossible-delivery promises, and the like.

This phase of the situation is brought out because it presents one of the great opportunities for the engineer or his representative to afford this individual a chance to get his troubles off his mind and to help him to realize that the situation is not hopeless after all.

[4] Manager, automotive department, Standard Oil Co. of Ohio, Cleveland.

Rubber Insulation for Motorboat Engines

(*Concluded from p.* 200)

such a nature that the vibrations oppose each other when the two are combined. The net results are a slowing down and straightening out of the lines in the chart. Naturally, the hardness of the rubber used enters into this appreciably. This fact was clearly shown by some work we did on an outboard engine. When we used very soft rubber, the absorption effect was actually visible. By placing the finger on the engine-support arm near but outside of the rubber insulation, we could very definitely feel and see the finger vibrating in a horizontal plane. But when the finger was placed on the frame between the rubber and the boat, no vibration was discernible at any engine speed. When very hard rubber was substituted for the soft installation, however, considerable vibration was shown to be carried through.

While the good qualities of rubber as a vibration dampener are self-evident, we must not lose sight of the fact that it has certain fundamental physical limitations. Being an organic substance it is subject to breakdown from oxidation. One of the cares we have constantly had to exercise for it in engine insulation is the avoiding of high temperatures. Both the compression and the adhesion type can be used in temperatures as high as 200 deg. fahr. without damaging effects; but temperature conditions higher than this should be avoided.

Rubber has a very definite load limit. Best results have been obtained when the load did not exceed 30 lb. per sq. in. of load-carrying surface when the insulator is used either in compression or suspension. In the adhesion type the standard bond or amount of adhesion between the rubber and metal is equivalent to 300 sq. in., giving a factor of safety of 10. If the rubber is either overheated or overloaded, it will have a pronounced tendency toward permanent distortion and premature disintegration.

Another important physical limitation of engine-insulation rubber is its inability to function regularly in oil without premature breakdown. Engine-insulation rubber is compounded to offer the maximum resistance to oil, but, even so, care must be taken to avoid exposing the surfaces of the rubber to oils if the best service is expected.

The experimentation on motorboat-engine insulation, up to the present, indicates that even better results can be predicted than have been accomplished on motor-vehicle engines. Results of experiments show that engine vibration, especially in craft in which it is very evident and objectionable, can virtually be eliminated with the right type and design of rubber. However, the scope of this work is so large that the results of partly finished experimentation should not be given at this time as final facts. The indications are, however, that a prediction bordering upon an assurance can be made that objectionable engine vibrations in motorboats will soon be a thing remembered as existing only in the past.

High-Speed Oil-Engines

By E. C. MAGDEBURGER[1]

BUFFALO AND PENNSYLVANIA SECTIONS MEETING PAPER *Illustrated with* PHOTOGRAPHS AND DRAWINGS

THIS paper, which was presented at meetings of the Buffalo and Pennsylvania Sections, begins with a statement of the advantages sought in adapting the Diesel cycle and developing oil engines to operate at high rotative speeds. Oil engines are classified according to their means for injecting and burning the fuel, and disadvantages attributed to the various systems are listed. Then follow descriptions of a number of engines of the different classes, selected according to the contribution their designs have made to the art. Particular attention is given to provisions for metering the fuel and for supercharging, which latter is said to have the same object as increasing the speed.

Discussion at the Buffalo meeting was on general problems of lubrication and fuel, on other methods for securing power from fuel oil, and on economic comparison of gasoline and oil engines.

Discussers at the Pennsylvania meeting turned to more specific subjects, such as motorcoach and aircraft applications and the problems of securing accurate and uniform metering of the fuel. More rapid progress was thought probable by turning to specialists for the development of the injection apparatus, as gasoline-engine builders have done for carbureters and electrical equipment. The relation of engine speed to atomization and maximum pressure was considered, with the conclusion that nothing inherent to the cycle limits the speed of an oil engine.

ENGINEERING science points to the ideal high-speed oil-engine of the future as the engine which will develop the most power from a given weight of materials and with the least expenditure of fuel. To make headway toward such an ideal requires the highest expression of man's genius in conquering the forces of nature, but the goal is so enticing that many enthusiastic engineers follow the procession which some day will arrive at this ideal. I shall review the achievements of these engineers, in the hope that new recruits will catch the glimpse of this, the most interesting and challenging problem of humanity today, and that greater steps toward success may follow. With this ideal in mind, important contributions toward the solution of the problem will be reviewed without going into the more common details of the engines considered. The terms oil engine and Diesel engine will be used indiscriminately herein to denote the type of engine in which the heat of compression is utilized for ignition.

The principal advantages of any Diesel engine are (*a*) its high thermodynamic efficiency, which can be best expressed in its ability to develop 1 b.hp.-hr. from as little as 0.36 lb. of fuel or to convert 30 to 35 per cent of its thermal energy into mechanical energy; (*b*) its ability to burn fuels of higher specific gravity and lower cost than are required by the gasoline engine; (*c*) its instant readiness to start and develop full rated power within a few minutes, which it possesses in common with the gasoline engine; (*d*) the same low fuel consumption may be obtained in a cylinder of 1 hp. as in a giant of 2500 hp.; and (*e*) a flat fuel-consumption curve, the consumption varying but little with the changes in load between full load and say one-half load.

When compared with gasoline engines, the advantages of the oil engine further include (*a*) the use of non-inflammable fuel, and therefore safety of operation, and (*b*) the elimination of spark-plugs, magnetos and other electrical appliances required for ignition,

[1] Aide on Diesel engines, Navy Department, City of Washington.

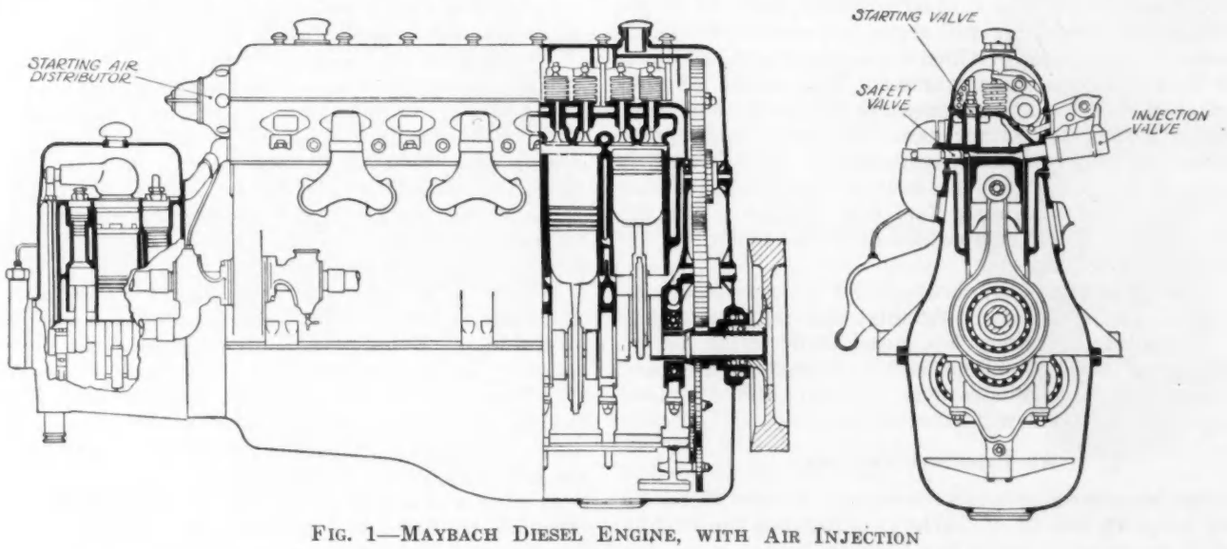


FIG. 1—MAYBACH DIESEL ENGINE, WITH AIR INJECTION

TABLE 1—DATA ON HIGH-SPEED OIL-ENGINES

Line	Engine	Cycle	No. of Cylinders	B.H.P. Per Cylinder	B.H.P. Total	Bore In.	Stroke In.	R.P.M.	Displacement, Cu. In.	Piston Speed, Ft. Per Min.	Brake M.E.P., Lb. Per Sq. In.	Specific Volume, Cu. Ft. Per B. Hp. Per Min.	Weight, Lb. Total	Weight, Lb. Per B.Hp.	Weight, Lb. Per Cu. In.	Fuel Consumption Per B.Hp.	Type of Injection[a]	
1	Atlas-Imperial	4	4	20	80	7	8½	650	1,308	921	74.5	6.15	4,600	57.5	3.52	0.42	2	1
2	Atlas-Imperial	4	6	20	120	7	8½	650	1,962	921	74.5	6.15	6,600	55.0	3.36	0.42	2	2
3	Attendu	2	2	42.5	85	5½	6½	1620	308.9	1755	67.4	3.41	477	4.9	1.54		3	3
4	Beardmore	4	8	81	650	8¼	12	1000	5,140	2000	107.5	4.58	4,600[b]	7.1	0.895	0.385	3	4
5	Benz	4	6	11.7	70	4.13	6.5	1300	522.5	1409	81.6	5.62	1,600	22.9	3.06	0.456; 0.558	4	5
6	Bessemer	4	6	33.3	200	7½	10½	650	2,782	1138	87.6	5.24	8,200[c]	41	2.95	0.43; 0.45	2	6
7	Brotherhood-Ricardo	4	6	50	300	7½	12	1000	3,180	1800	74.7	6.14	12,000	40	3.78	0.38	3	7
8	Buda-M.A.N.	4	4	23	92	6	8	1000	904.5	1333	80.6	5.69	3,200	34.8	3.54	0.435	3	8
9	Buda-M.A.N.	4	6	30	180	6½	8¾	1000	1,742	1458	81.85	5.6	5,425	30.3	3.12	0.435	3	9
10	Climax-McCarty	2	6	50	300	7½	10	600	2,650	1000	74.8	3.07	12,000	40	4.53		1[d]	10
11	Colo-Diesel	4	6	10	60	5	7	750	825	875	76.8	5.97	2,200	36.6	2.67		4	11
12	Cummins	4	6	10	60	4½	6	1000	572.5	1000	83.0	5.52	2,200	36.7	3.84		4	12
13	Cummins	4	6	28.3	170	6¾	9	800	1,931	1200	87.2	5.26	5,000	29.4	2.59		4	13
14	Cummins	4	6	83.3	500	10	12	800	5,655	1600	87.6	5.24	14,500	29.0	2.56		4	14
15	Deutz	4	6	14.1	85	4.53	6.69	1250	646	1394	83.3	5.5	1,632	19.2	2.53	0.425	4	15
16	Dorner	4	4	7.5	30	3.74	6.30	1000	277	1048	85.8	5.34				0.479	3	16
17	Fairbanks-Morse	2	4	15	60	6	6½	800	735	867	40.4	5.68	3,940	65.7	5.36		4	17
18	Hill	4	6	12.5	75	5	7	1000	824.7	1166	72.0	6.37	3,920[e]	50.0	4.75	0.5	4	18
19	Hill	4	6	20	120	6	10	800	1,696.4	1333	70.0	6.54	7,500[e]	58.6	4.42	0.5	4	19
20	Ingersoll-Rand	4	6	50	300	10	12	550	5,653	1100	76.4	6.0	19,000	63.3	3.36	0.44	3[f]	20
21	Ingersoll-Rand	4	6	137.5	825	14¾	16	500	16,400	1333	79.7	5.76	45,000	54.6	2.74	0.44	3[f]	21
22	Junkers	2	2[g]	32.5	65	3.15	7.9+7.9	1000	246.1	1316	104.5	2.19	610	9.5	2.48		3	22
23	Koerting	4	6	15.0	90	5.1	7.1	1200	880	1420	67.5	6.79	3,300	36.0	3.75		4	23
24	Linke-Hoffmann	4	4	12.5	50	4.5	6.5	1200	410	1300	80.0	5.7	1,100	22.0	2.7		3	24
25	Maybach	4	6	25	150	5½	7⅛	1300	1,015	1544	90.1	5.09	2,650	17.7	2.61	0.40; 0.49	1	25
26	Peugeot	2	2	26.5	53	4.7	5.9	1450	204.8	1426	70.5	3.25	530	10.0	2.59		3	26
27	Speedway	4	6	50	300	8½	11	700	3,747	1284	90.2	5.06	7,600	25.3	2.03		2	27
28	Standard	4	4	15	60	6	8	650	904.5	867	80.9	5.67	3,500	58.3	3.87	0.43	2	28
29	Standard	4	6	21.6	130	6	8	900	1,356	1200	84.4	5.44	5,110	39.3	3.78	0.41	2	29
30	Treiber	4	12	250	3000	16	16	700	38,600	1867	87.8	5.22	63,200	21.1	1.64	0.42	2	30
31	Treiber	4	12	62.5	750	9½	12	700	10,210	1400	83.1	5.52	18,500	24.7	1.81	0.42	2	31
32	Westinghouse	4	6	50	300	8¼	12	800	3,850	1600	76.0	5.94	12,000	40.0	3.12	0.40	3	32
33	Westinghouse	4	12	111.6	1340	12	12	800	16,290	1600	81.4	5.63	33,500	25.0	2.06	0.40	3	33
34	Winton	4	6	25	150	7	8½	750	1,963	1062	80.7	5.68	5,700	38.0	2.9	0.44	2	34
35	Winton	4	6	41.6	250	8	10	750	3,019	1250	87.5	5.24	7,400	29.6	2.45	0.44	2	35
36	Winton	4	8	53	425	8½	12	700	5,445	1400	88.3	5.19	13,000	30.5	2.39	0.44	2	36

[a] Types of fuel injection: (1) air injection, (2) constant-pressure fluid-injection, (3) direct-pump fluid-injection, (4) precombustion-chamber injection. [b] Weight 3600 lb. with aluminum crankcase. [c] Weighs 10,000 lb. in cast iron. [d] Fuel injection with heated air. [e] Includes reverse-gear and electric starter. [f] Opposed sprays, Price system. [g] Opposed pistons.

including the batteries unless these are used for starting the engine by means of an electric motor.

The main reason for the high-speed type of oil engine is the same as for any high-speed machinery; that is, the saving in space and weight through increased rotative speed.

If saving in weight and space is the principal objective of the use of high rotative speed, other means which accomplish the same end would naturally be incorporated in the design of high-speed oil-engines. The number of such means used and the degree of their refinement determine the rung of the ladder to which any given effort belongs and its proximity to the ideal above mentioned. The fuel consumption and the weight per brake horsepower will serve as yardsticks. These, together with other pertinent data, have been assembled in Table 1 for quick comparison. The available figures are published without comment or reference to the conditions under which they were obtained. Some manufacturers have refused permission to publish any of their data because of the lack of uniformity of test conditions for obtaining fuel consumption. For the same reason, direct comparison of fuel-consumption figures is inconclusive.

Most prospective applications of a high-speed oil-engine require that it be flexible; that is, that it shall run smoothly at a very low speed while idling and at any speed between idling and full power under any load. This is a considerable problem, and its many ingenious solutions will be reviewed.

Air-Injection Engines

The Maybach four-cycle oil-engine, shown in Fig. 1 and listed in line 25 of Table 1, is perhaps the first in which heavy-oil burning has been applied to a modern high-speed light-weight multi-cylinder engine. Since its introduction, in 1923, it has been built in only one size, developing a maximum of 150 b.hp. at 1300 r.p.m., with a fuel consumption of 0.40 to 0.49 lb. per b.hp-hr. This engine has many interesting mechanical features, such as the use of roller-bearings for the seven main bearings and the crankpins, and air intake through the crankcase for deadening the intake noise and ventilation of the crankcase; but fuel injection by means of high-pressure air, compressed in a separate three-crank three-stage air-compressor, has been retained from the conventional type of Diesel engine. Compression pressure of 550 lb. per sq. in. has been adopted, and injection-air pressure up to 1500 lb. per sq. in. and starting-air pressure of 800 lb. per sq. in. are required.

The fuel valves of the engine have a constant lift; but unique means have been developed for automatically changing the cross-section of the nozzle in accordance with the load, and a pressure regulator is provided to control the injection-air pressure to suit the engine speed. This makes the engine adjustable to a wide range of torque and speed and suitable for operation by remote control or bridge control. Safeguards against disagreeable and often dangerous vibration are careful attention to the balance of all rotating and reciprocating parts and the use of a torsional-vibration damper on the forward end of the engine, which make the high speed of the engine possible. The fuel-pump is a unique structure of vertical plungers pressed by springs against a common wabble-plate driven by a vertical shaft. Changing the inclination of this plate changes the effective stroke of the pump plungers.

A large number of these engines are reported to be installed in rail-cars operating on German, Danish, Swedish and Hungarian railroad systems. Schedules re-

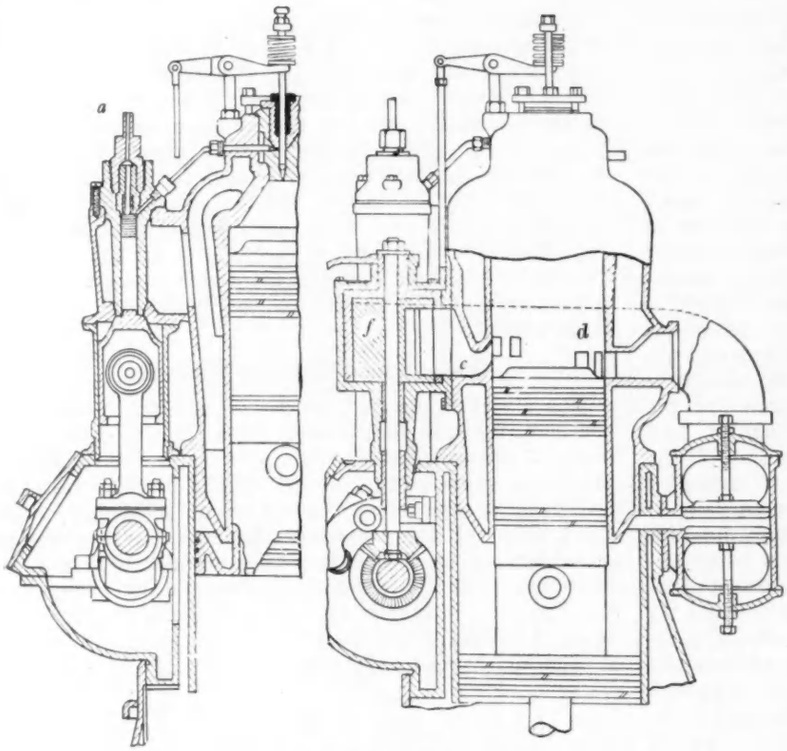


FIG. 2—CLIMAX-MCCARTY ENGINE, WITH STEPPED PISTON

high-speed engines must be attributed to Hindl, one of the original collaborators of Diesel, who built a number of motor-boat engines in Austria during the war. His system of fuel injection by means of hot high-pressure air has been applied to a two-cycle engine developed by Norman McCarty for the Climax Engineering Co., of Clinton, Iowa. The essential features of this engine are shown in the cross-sections of Fig. 2, and the data are given in line 10 of Table 1. A small amount of air at a pressure of 215 lb. per sq. in. is delivered by an independent air-compressor to the suction line *a* of the engine-injection air-compressor, of which there is one for each working cylinder, driven from the common camshaft of the engine. Here the air is compressed to a pressure of about 1100 lb. per sq. in., and it is forced through the fuel valve and into the cylinder in a highly heated condition, the pressure rising to about 1300 lb. per sq. in. at the end of injection.

A fuel consumption of 0.47 lb. per b.hp.-hr. is claimed[2] for this engine. A special feature is the mechanically operated rotary valve *b*, Fig. 2, controlling scavenging and supercharging of the working cylinder. It will be noted that the scavenging ports *c* remain open after the piston, on its upward stroke, has closed the exhaust ports *d*, so that supercharging is possible up to the scavenging-receiver pressure. Furthermore, valve control of the scavenging makes possible adapting the time allowed for scavenging to the speed of the engine, so that no waste of air need occur at slow speeds when the ports remain open longer. Without control, more air would flow through the ports and out into the exhaust, until the compression pressure might become too low for reliable ignition.

Whether the use of a stepped piston for furnishing scavenging air contributes to the reliability of the engine is debatable. Suffice it to say that it was abandoned by a number of engine builders, and experience with some early submarine engines[3] using this construction was unsatisfactory.

quiring 18 hr. of operation out of every 24 hr. are being maintained on some of these.

A previous successful attempt to use heavy oil in

[2] See *Power*, March 12, 1929, p. 429.

[3] See *Journal of American Society of Naval Engineers*, August, 1925, p. 572.

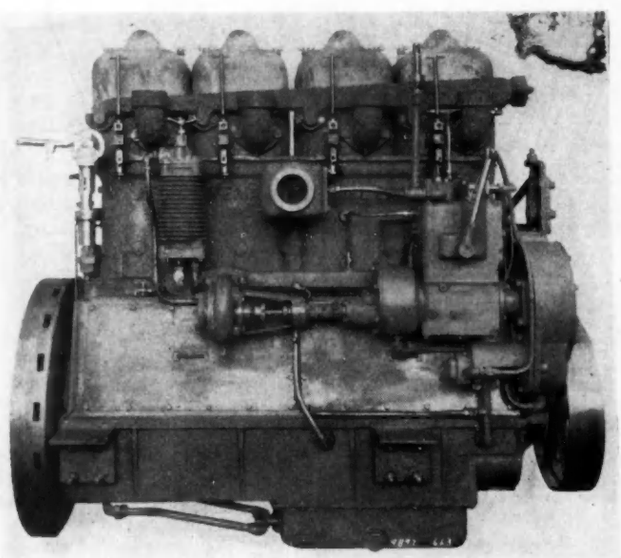


FIG. 3—ATLAS-IMPERIAL ENGINE FOR CONTRACTORS' MACHINERY

The Fuel-Pump Is Seen at the Right. The "Common Rail" Is on the Opposite Side of the Engine, Concealed by a Cover-Plate. Visible also Are the Safety Valves Provided for Each Cylinder. This Engine Has Four 7 x 8½-In. Cylinders and Is Rated at 80 Hp. at 650 R.P.M.

Airless Injection of Fuel

The most obvious means of saving weight and space is by doing away with the injection-air compressor. Much experimental work has been done to this end since 1910, when McKechnie, of Vickers, Ltd., seriously took up the idea. Dr. Diesel tried it but soon discovered in high-pressure air

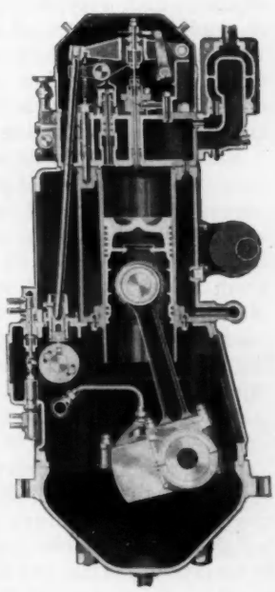


FIG. 4—COOPER-BESSEMER ENGINE

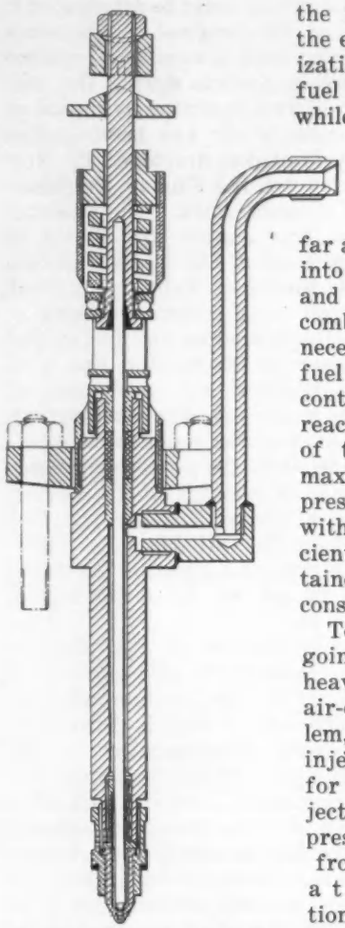


FIG.5—FUEL-INJECTION VALVE OF COOPER-BESSEMER ENGINE

the ideal agency for storing the energy required for atomization or breaking up the fuel oil into suitable droplets while passing through the fuel valve when the needle is lifted; for penetration, or carrying these droplets as far as required from the valve into the combustion space; and for turbulence within the combustion space, which is necessary for bringing the fuel droplets into intimate contact with oxygen for the reaction of combustion. All of this is necessary if the maximum mean indicated pressure is to be developed within the cylinder and efficient combustion is to be obtained with the lowest fuel consumption.

To produce all of the foregoing phenomena without the heavy and often troublesome air-compressor is a real problem, and two distinct types of injection have been developed for its solution: first, fluid injection, which relies upon the pressure of the oil issuing from the injection valve for atomization and penetration while using other means to promote turbulence of the air charge and efficient combustion, and, second, gas injection, which depends upon gases of partial combustion in a precombustion-chamber for atomization and penetration of the main fuel charge, with or without other means to create turbulence of the air charge.

Fluid injection in turn can be subdivided into two different methods: (*a*) constant-pressure fluid injection, which depends upon fuel maintained under pressure of 2000 to 8000 lb. per sq. in. in a manifold from which the individual cylinders receive their charges by means of mechanically operated needle-valves, the latter doing the metering of the charges; and (*b*) variable-pressure or direct-pump fluid injection, in which the pump does both the metering and the injection, either through a spring-loaded needle-valve at the cylinder or through an open passage leading into the cylinder.

Each of these methods has its advantages and disadvantages and therefore its partisans. Before proceeding further with the description of individual systems of airless injection, the disadvantages of each as viewed by the proponents of its competitor will be cited so that later these can be checked and their probable importance estimated.

Constant-pressure fluid injection has the following disadvantages: (*a*) With fuel under constant high pressure in the manifold, the slightest leak in the injection valve will cause dripping; this will cause smoky exhaust, deposit coke on the piston and gum up the piston-rings. (*b*) Metering minute quantities of fuel by keeping the injection valve open for a definite time is hardly reliable, since it fails to account for changes in the orifice of the valve due to erosion or clogging. (*c*) The injection control by the lift of the valve is extremely sensitive; hence continuous changing of the adjustment of the valves for the individual cylinders is necessary.

Using the Pump for Metering

The direct-pump system employs a pump to do all of the metering and the timing of the fuel injection. The metered charge passes at the proper time through the discharge valve of the fuel-pump and directly into the cylinders of the engine or through a spring-loaded check-valve at the cylinder. Among the troubles to guard against are: (*a*) after-dripping, due to secondary discharge from the pressure waves and air pockets in the line, and sluggishness of valve-seating; (*b*) misfiring, because of air in the fuel; (*c*) variation of injection lag, from compressibility of the oil and breath-

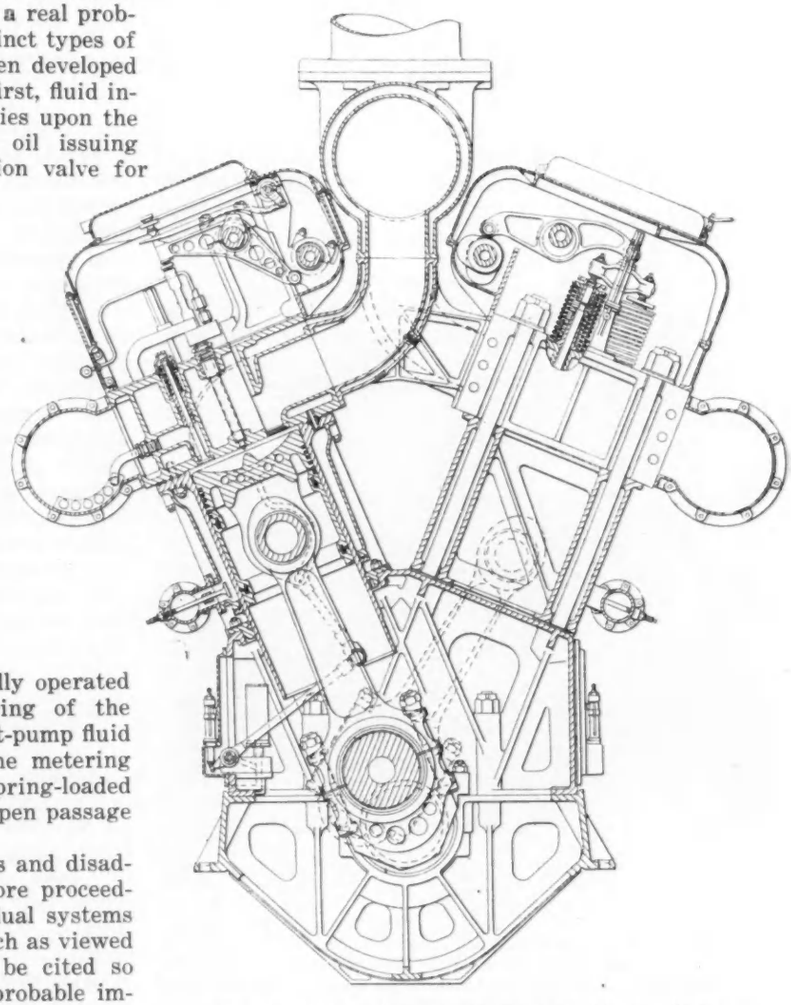


FIG. 6—CROSS-SECTION OF TREIBER DIESEL ENGINE

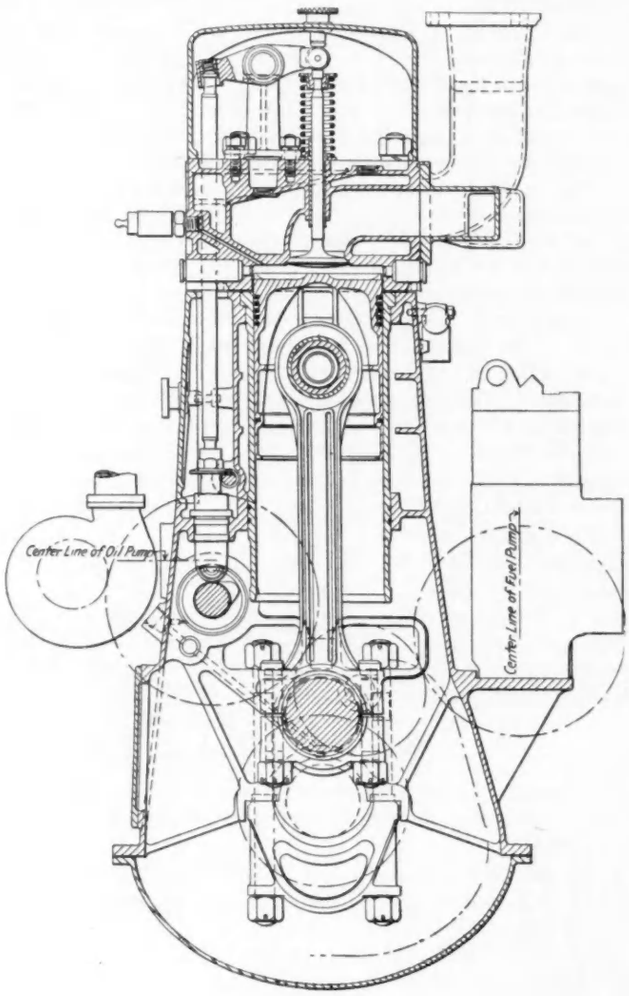


FIG. 7—BUDA-M. A. N. ENGINE

ing of the pipes leading from the fuel-pump to the cylinder.

Precombustion-chamber injection comprises essentially a chamber, cup or cavity, connected with the combustion space in the cylinder either by a number of small holes or by one large hole, into which a pump injects the fuel through a spring-loaded needle-valve. The gases resulting from the combustion of a small part of the charge supply the necessary energy for atomizing and distributing the remainder of the fuel charge through the main combustion space in the cylinder. With the injection-chamber method, as viewed by Dr. Wilhelm Riehm, of the Maschinenfabrik Augsburg-Nürnberg, an advocate of another system of injection, "the timing of the injection requires much more serious consideration than in pressure atomization." He further states[4] that a spring-loaded valve "involving a number of delicate parts is an inconvenience in manufacture and does not promise reliability of operation. Especially the nozzle tip, in which are the valve-seat and the ports, and the needle-valve are subject to great wear." Of course, part of the foregoing criticism applies to any but the open-nozzle type of fuel valve employed in M.A.N. engines.

With these criticisms as a guide, engines employing the various airless fuel-injection methods will be reviewed.

Constant-Pressure Fluid Injection

The system of fluid injection from a supply at constant pressure was originally introduced by McKechnie on submarine engines of Vickers manufacture. It has been adopted during recent years by a number of Diesel-engine builders in this Country for their established product and used also on their high-speed models. It consists essentially of a "common rail" or fuel manifold containing fuel under pressure of from 2000 to 8000 lb. per sq. in., a constant-stroke fuel-pump and variable-lift injectors mounted on each working cylinder.

The pressure in the system is maintained by one or more accumulators which often are round steel flasks having elastic walls that reduce pressure fluctuation. The fuel-pump, which for the sake of uniformity of pressure often consists of three individual plungers timed 120 deg. apart, delivers a constant quantity of fuel into the pressure manifold, from which the excess of fuel is returned to the suction side of the pump through a relief-valve set at a given pressure. The metering of the charge is done by mechanically operated injection-valves controlled by a governor or a throttle, or both. Throttling is effected by reducing simultaneously the time of injection and the pressure maintained in the manifold.

A number of manufacturers of high-speed oil-engines in this Country have adopted this system for the sake of its simplicity. The oldest high-speed engine using

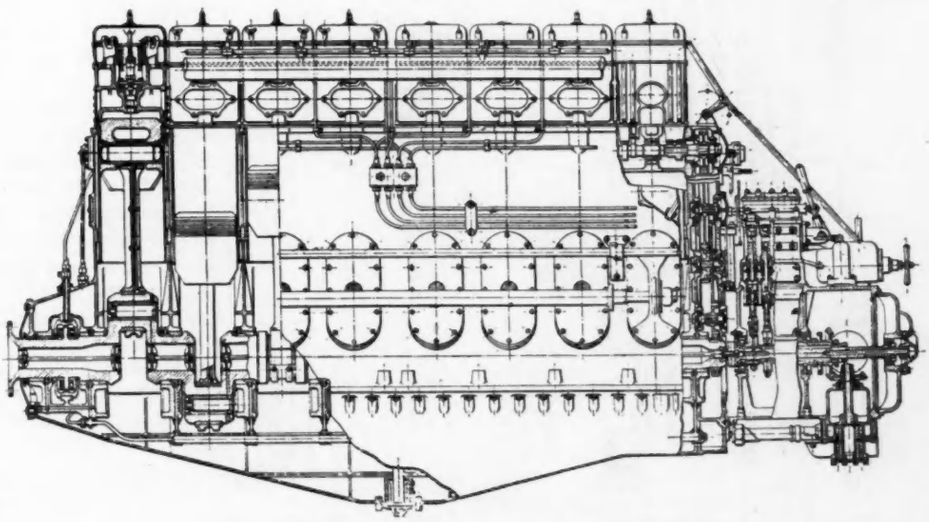


FIG. 8—BEARDMORE ENGINE FOR AIRSHIP R-101

[4] See THE JOURNAL, May, 1928, p. 526; and TRANSACTIONS, vol. 23, 1928, part I, p. 132.

this type of fuel injection is the Atlas-Imperial engine, which has been used extensively by a prominent manufacturer of excavators. It presents nothing radical in design but has a successful record of seven years. Line 1 of Table 1 gives the essential details of this engine. The engine shown, in Fig. 3, is a recent model.

The Winton Engine Co. uses this type of fuel injection in its high-speed models, although it continues to manufacture its older line of air-injection engines. The dimensions of three engines of this type are given in lines 34 to 36 of Table 1. Twin valves are used for both inlet and exhaust, with the fuel valve in the center.

The Consolidated Shipbuilding Corp. has recently placed on the market a high-speed Speedway engine using this type of fuel-injection system. Line 27 of Table 1 gives some of the data pertaining to this engine. The Standard Motor Construction Co. also builds small high-speed engines, details of which are given in lines 28 and 29 of Table 1, with this type of fuel injection.

The Bessemer Engine Co. has built one high-speed eight-cylinder V-type engine for railway service and is manufacturing a line of engines the cross-section of one of which is shown in Fig. 4. At the top of Fig. 4 can be seen the little wedge used to vary the lift of the valve for metering the oil. Line 6 of Table 1 gives the numerical data, and the type of spring-loaded valve developed by this company is shown in Fig. 5.

The most courageous attempt to reduce the weight of a large engine through special design and materials, V arrangement and constant-pressure fuel injection was made by O. D. Treiber[5]. He designed a 3000-hp. engine to weigh 63,900 lb., the cross-section of which is shown on Fig. 6. I know of no published data on the tests of the first pair of these engines built and do not know whether the hopes of the designer were realized. Line 30 of Table 1 gives the essential figures for this engine and line 31 of another size, a pair of which was recently installed in the yacht *Vara*. The Treiber Diesel Engine Corp. is also developing a radial engine of about 500 to 600 b.hp.

A number of engine builders resort to the direct-pump system of fuel injection for their high-speed oil

[5] See THE JOURNAL, February, 1928, p. 183; and TRANSACTIONS, Vol. 23, 1928, part I, p. 125; also *Transactions of the Society of Naval Architects & Marine Engineers*, vol. 35, 1927, p. 235.

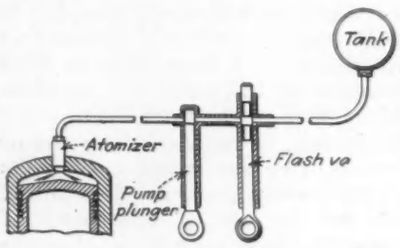


FIG. 9—DIAGRAM OF BEARDMORE FUEL-PUMP

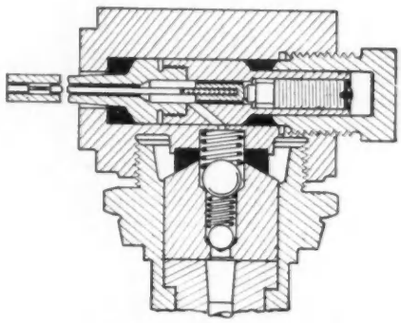


FIG. 13—DORNER FUEL-VALVE

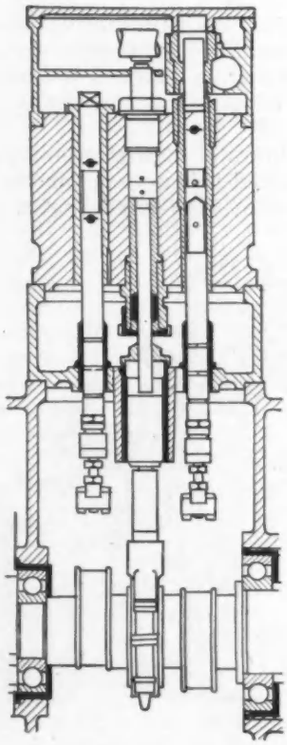


FIG. 10—SECTION OF WESTINGHOUSE FUEL-PUMP

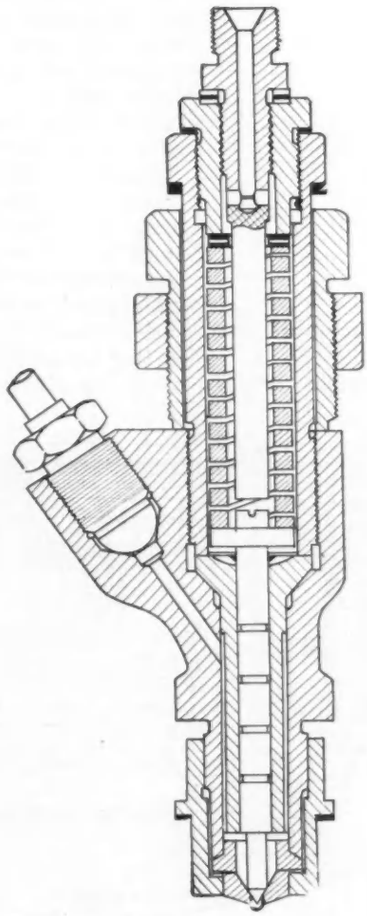


FIG. 11—WESTINGHOUSE-BEARDMORE FUEL-VALVE

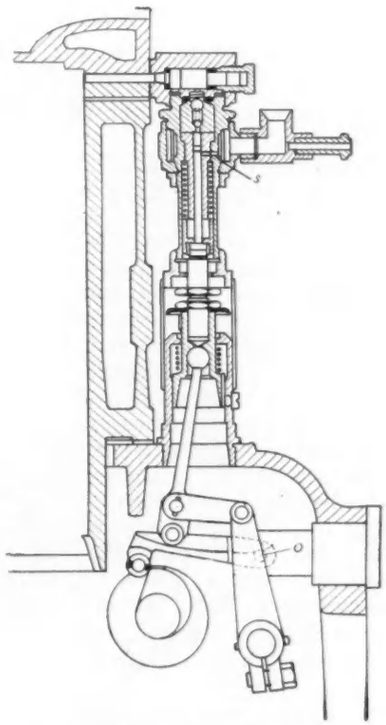
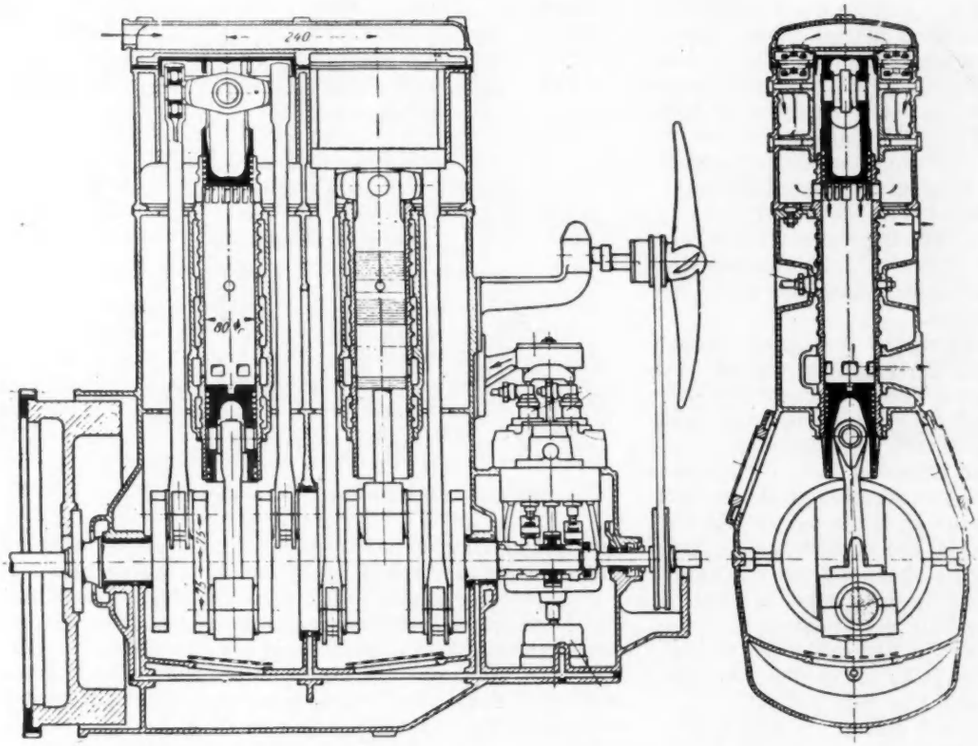


FIG. 12—DORNER FUEL-PUMP



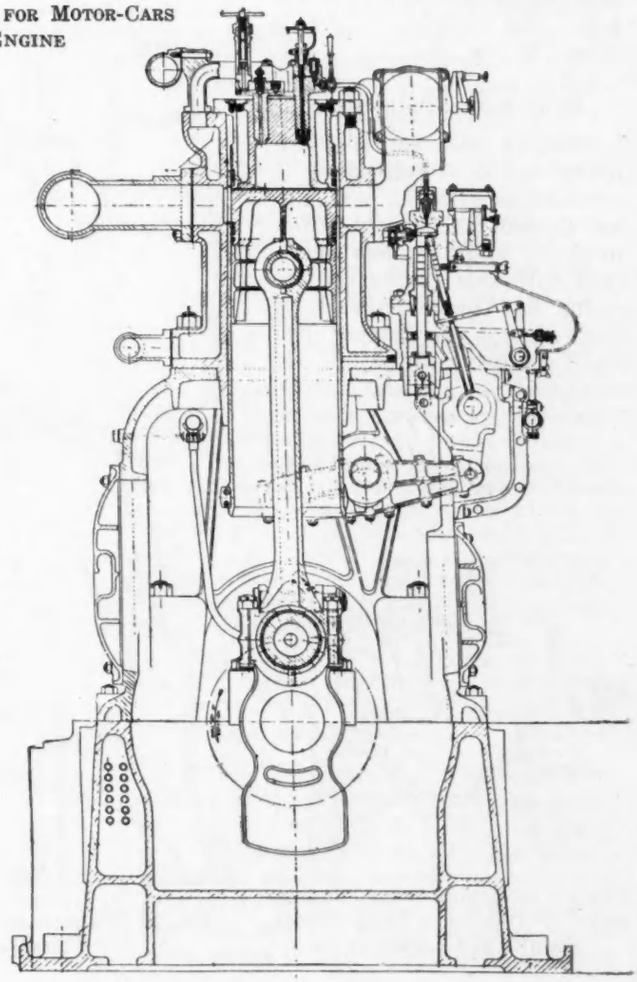


FIG. 14 (ABOVE)—JUNKERS OPPOSED-PISTON DIESEL-ENGINE FOR MOTOR-CARS
FIG. 15 (LOWER RIGHT)—BROTHERHOOD-RICARDO DIESEL-ENGINE

engines, and much ingenuity is developed to overcome the objectionable features of such a system that have been cited herein. Among the first to build a high-speed engine having this system was the Maschinenfabrik Augsburg-Nürnberg, of Germany. Much has been published[6] in both German and English about the German and American engines of this type.

Direct-Pump Fuel Injection

Fig. 7 shows the cross-section of the Buda M.A.N. type of engine. The fuel-pump is on the right and the water-pump on the left side. Two injectors are used in each cylinder of the Buda engines, but only one in M.A.N. engines of the later designs. This injector consists of only three simple parts and is easily dismountable. It is of the open type and has no moving parts or springs. The direction of the sprays within the cylinder is given by a tip through which pass several fine orifices for atomizing the fuel. One passage only about 0.006-in. in diameter leads through the injector to the tip. The fuel-pump is mounted low, so that the fuel column goes only upward and leaves no chance for the formation of air pockets. This pump was fully illustrated and described, including the means for regulating the time and quantity of the injection, in a paper by Dr. Rhiem[7]. Lines 8 and 8 in Table 1 give particulars of two engine sizes manufactured by the Buda Co. A large number of engines of the M.A.N. type have found their way into rail-cars, trucks, excavators, motorboats and industrial installations, in both this Country and Europe.

Another notable development with this type of fuel injection is the Beardmore engine, which is manufactured in this Country by the Westinghouse Electric & Mfg. Co. A recent paper[8] by A. E. L. Chorlton, the designer of the original engine, gives pictures of the latest development of this type for the British airship R-101. Fig. 8 shows the main features of the design, and line 4 of Table 1 gives the numerical data.

The fuel-oil pump employed in the Westinghouse-Beardmore engine is the most characteris-

[6] See THE JOURNAL, May, 1928, p. 526; and TRANSACTIONS, vol. 23, 1928, part I, p. 132; also S.A.E. JOURNAL, February, 1928, p. 177; and TRANSACTIONS, vol. 23, 1928, part I, p. 119.

[7] See THE JOURNAL, February, 1928, p. 177; and TRANSACTIONS, vol. 23, 1928, part I, p. 119.

[8] See *Engineering*, Sept. 21, 1928, p. 375, and Oct. 5, 1928, p. 441.

tic feature of the whole design, and its main feature is the control valve. The basic idea of this pump, shown schematically in Fig. 9, is that the metering of minute quantities of fuel cannot be entrusted to conventional suction and discharge valves, so positive control of inlet and discharge is provided by a separate plunger or control valve, which reciprocates in phase with the main plunger. This plunger has two annular cavities, interconnected through holes into its hollow body, and a central belt of full diameter. During the suction stroke of the pump plunger, oil is drawn first through the upper and then through the lower annulus, while the control valve is also descending.

At the time injection is required, the pump plunger is moving upward at nearly its maximum speed. Injection begins when the central belt of the control valve, on its upward stroke, blocks the inlet passage, and continues until the belt uncovers the passage again. Timing of the beginning of injection is constant, and its duration is varied by a slight rotation of the control valve, which has a helical edge at the lower side of the central belt and is controlled by the governor. The fuel-pump is coupled to the engine shaft and each plunger is made to serve two working cylinders through a switch valve operated at one-half engine-speed and connecting one or the other of the two cylinders served. In Fig. 10, the pump plunger is in the center; the control valve is at the right, with the rack for rotating it occupying the incomplete circle beside its upper end; and the switch valve is at the left. The injection valve is shown in Fig. 11.

Beardmore Applications

The fuel consumption of the R-101 engine at full power is reported as 0.385 lb. per b.hp-hr. Considerable trouble from torsional vibration has developed with this engine and its rating had to be reduced on that account. A damper flywheel is being fitted to the crankshaft[9] at the end remote from the propeller, also a spring coupling, of stiffness so calculated as to bring the major critical speed far below the running range.

[9] See *Journal of the Royal Aeronautical Society*, March, 1929, p. 179.

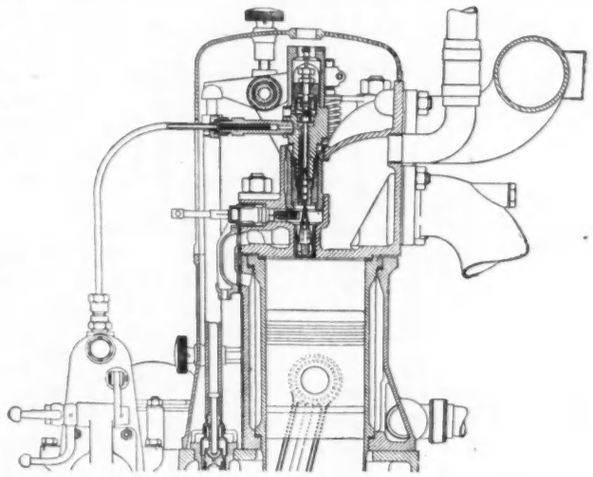


FIG. 19—DAIMLER-BENZ VEHICLE OIL-ENGINE

A number of engines of similar type have been fitted into locomotives by the parent company and its American licensee. In operation now on the Canadian National Railways are five six-cylinder, two eight-cylinder and seven four-cylinder engines; as well as one large articulated locomotive, housing in each cab one twelve-cylinder V-type engine rated at 1340 b.hp. at 800 r.p.m., another articulated locomotive with two six-cylinder 300-hp. 800-r.p.m. engines, and a switching locomotive with one such engine. The Westinghouse company has an order for seven 350-hp. engines for rail-cars and one 450-hp. engine for a locomotive of the Canadian National Railways, according to figures given by D. W. R. Morgan at a meeting of the Pennsylvania Section of the Society in March, 1929.

The important changes in design

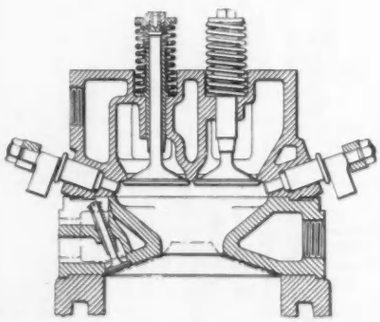


FIG. 16—CYLINDER-HEAD ARRANGEMENT OF INGERSOLL-RAND DIESEL-ENGINE FOR LOCOMOTIVES

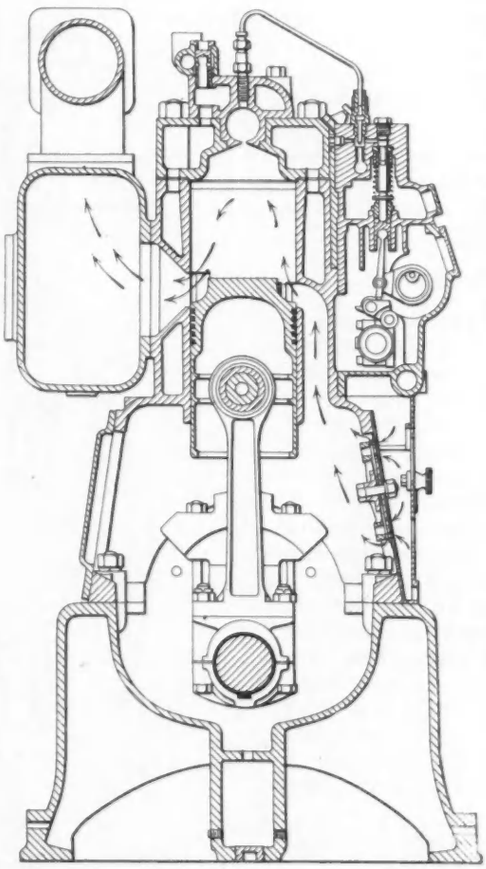


FIG. 17—FAIRBANKS-MORSE TWO-CYCLE DIESEL-ENGINE

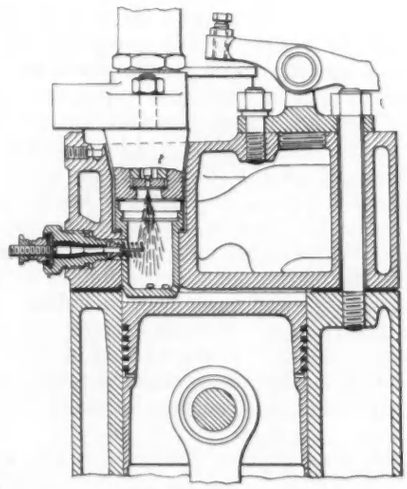


FIG. 18—PRECOMBUSTION-CHAMBER OF DEUTZ ENGINE

made by the Westinghouse company include the reduction in the number of operating plungers of the fuel-pump for a six-cylinder engine from nine to six. This was done by running the fuel-pump at one-half engine speed and eliminating the switch or transfer valve, so that each cylinder is provided with its own fuel-pressure and metering device. Equal distribution of the load between the engine cylinders, which is extremely important in high-speed engines, is given as the reason for the departure from the original design.

Constant-Volume Combustion Utilized

The mysterious Packard radial Diesel aircraft-engine, which also depends upon the same method of fuel injection, on Sept. 19, 1928, was the first oil engine in this Country to go into the air[10]. In May, 1929, it made a non-stop 650-mile trip from Detroit to Langley Field. Nothing authentic has been published[11] about this engine, except that a German engineer, Dr. Dorner, had a hand in designing its fuel-injection system. Dr. Dorner has designed in Germany a high-speed automotive Diesel engine on which a comprehensive report by Prof. Kurt Neumann has been published[12]. It is assumed that the same fuel-injection system has been employed in the Packard engine. The sustained rating of the Packard engine is 200 hp., and it weighs 600 lb., 3 lb. per hp.

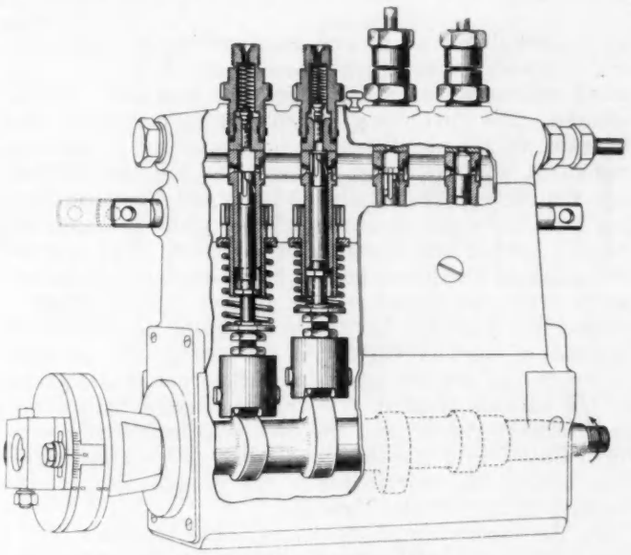


FIG. 20—BOSCH FUEL-PUMP

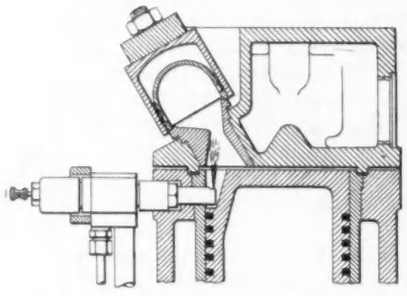


FIG. 21—OUTSIDE-STORAGE CHAMBER OF BOSCH-ARCO ENGINE

[10] See *Journal of the American Society of Naval Engineers*, August, 1924, p. 523.

[11] See *Oil Engine Power*, June, 1929, p. 328.

[12] See *Zeitschrift des Vereins Deutscher Ingenieure*, May 28, 1927, p. 775; translated in National Advisory Committee for Aeronautics Technical Memorandum No. 467.

[13] See *Oil Engine Power*, April, 1928, p. 263.

A distinctive feature of the Packard radial engine is the use of only one centrally located valve, which is opened when the exhaust valve normally should open and closed when the inlet valve should seat. This valve communicates with a continuous passage in the cylinder-head. Assisted by the flow of air from the propeller, the exhaust gases escape to the rear and fresh air is drawn in from the front through the valve.

In an article on aircraft Diesel engines, A. B. Thiemann[13] says of the Packard engine:

> As reason for the single-valve design is given the inability of providing large enough valve areas, with one inlet and one exhaust valve, to properly fill the cylinder at the high speeds of the engine. However, for the 1600 to 1700 r.p.m. of this engine, the above reason does not sound plausible. An experimental single-valve cylinder for aircraft propulsion was built in Germany during the war; but it was abandoned, excessive exhaust noise due to suddenly opening large exhaust areas being not the least among the reasons for so doing.

Henry Ford also is engaged in designing and testing oil engines for aircraft, but he is not yet ready to make any announcement about them.

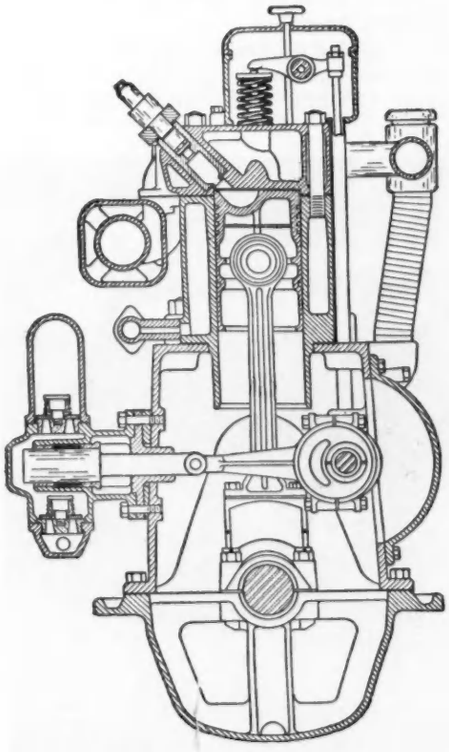


FIG. 22—HILL ENGINE WITH PRECOMBUSTION CHAMBER

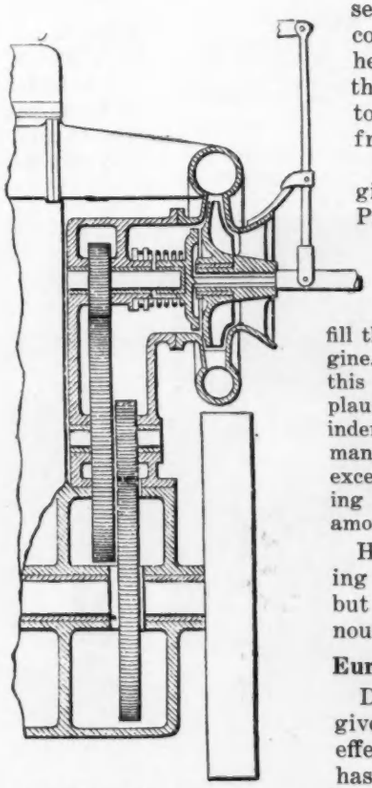


FIG. 23—GEAR DRIVE FOR SUPERCHARGER ON BEARDMORE ENGINE

European Prototype of Packard Engine

Data on the original Dorner engine are given in line 16 of Table 1. A brake mean effective pressure of 95.5 lb. per sq. in. has been maintained, with only 21-per cent excess of air. Credit for performance has been ascribed to the constant-volume cycle, which brings the explosion pressure

up to 1000 lb. per sq. in. and even more, and incidentally may furnish all the turbulence required for the thorough utilization of air charge that has been demonstrated. The fuel-pump, which has to maintain combustion on the dead center, is driven by a separate camshaft, and the pump and injector are merged into one structure. Figs. 12 and 13 show the details, including how the pump stroke is altered while maintaining correct timing and duration of injection. The further the roller at the lower end of lower push-rod is moved away from the center *o*, the greater is the effective stroke, but it always has the same timing and duration. Instead of suction valves on the pump, the plunger uncovers the suction port *s* and the fuel is drawn in by the vacuum created. Two hardened-steel balls serve as discharge valves; and the fuel, passing them, enters immediately into the injector, which is a poppet valve that follows the movements of the plunger accurately, because of its extreme lightness.

In the beginning of February, 1929, another high-speed oil-engine took the air, this time in Germany, where a Junkers opposed-piston engine has finally been mounted in a plane and made several successful flights. The six-cylinder engine develops a maximum of 700 b.hp. and its speed of 1600 r.p.m. is reduced by gears to 1120 r.p.m. for the propeller. It weighs 1780 lb. dry, or about 2½ lb. per b.hp. The full-power fuel-consumption of this engine was determined on test to be 0.397 lb. per b.hp-hr. while running on gas-oil. No further data are yet available on the aircraft model. A cross-section of a two-cylinder automotive engine[14] of the same type is reproduced in Fig. 14, and the pertinent figures are given in line 22 of Table 1.

Diesel Engine Designed by Ricardo

Any degree of turbulence can be obtained in a Junkers type of engine by varying the slant of the ports to regulate the tangential whirls.

[14] See *The Motorship*, February, 1929, p. 430.

H. R. Ricardo, the justly famous designer of high-speed engines, has designed the high-speed oil-engine built by the Peter Brotherhood, Ltd. A cross-section of this engine is shown in Fig. 15, from which the construction details may be studied, and line 7 of Table 1 gives its numerical characteristics. This four-cycle engine is the first oil engine to use a steel sleeve valve, which controls both inlet and exhaust by its rotating and reciprocating motion. There is a separate fuel-pump for each cylinder, and injection pressure of about 5000 lb. per sq. in. is used. The weight of the complete engine in cast iron, including flywheel, is less than 40 lb. per b.hp. A fuel consumption of 0.38 lb. per b.hp-hr. is reported.

The honor of having put the first oil engine into a locomotive cab in this Country belongs to the Ingersoll-Rand Co., which has placed in service, since October, 1925, and is building a total of 35 locomotives of four different sizes; namely, 24 of 300 b.hp.; 9 of 600 b.hp., 1 of 750 b.hp., and 1 of 825 b.hp. Two different engines have been developed, both of six-cylinder four-cycle type. One develops 300 and the other 825 b.hp., and both use the well-known Price system of direct-pump fuel injection. This system is based upon the impinging of the two diametrically opposite sprays in the center of the combustion-chamber, the design of which, as shown in Fig. 16, embodies a neck through which the air charge flows at high speed to create the turbulence required for efficient combustion of the fuel charge.

Another distinguishing feature of this engine is its fuel system, employing one single-plunger pump, driven at three times engine speed for a six-cylinder engine and supplying all six cylinders through a fuel-oil distributor. The plunger of the fuel-pump, on the latter part of its downward stroke, pulls open the suction valve, which it engages by means of open hooks in both of these parts and a spring to keep the hooks engaged. The spring is compressed after the suction valve seats, and discharge occurs through a discharge valve and is

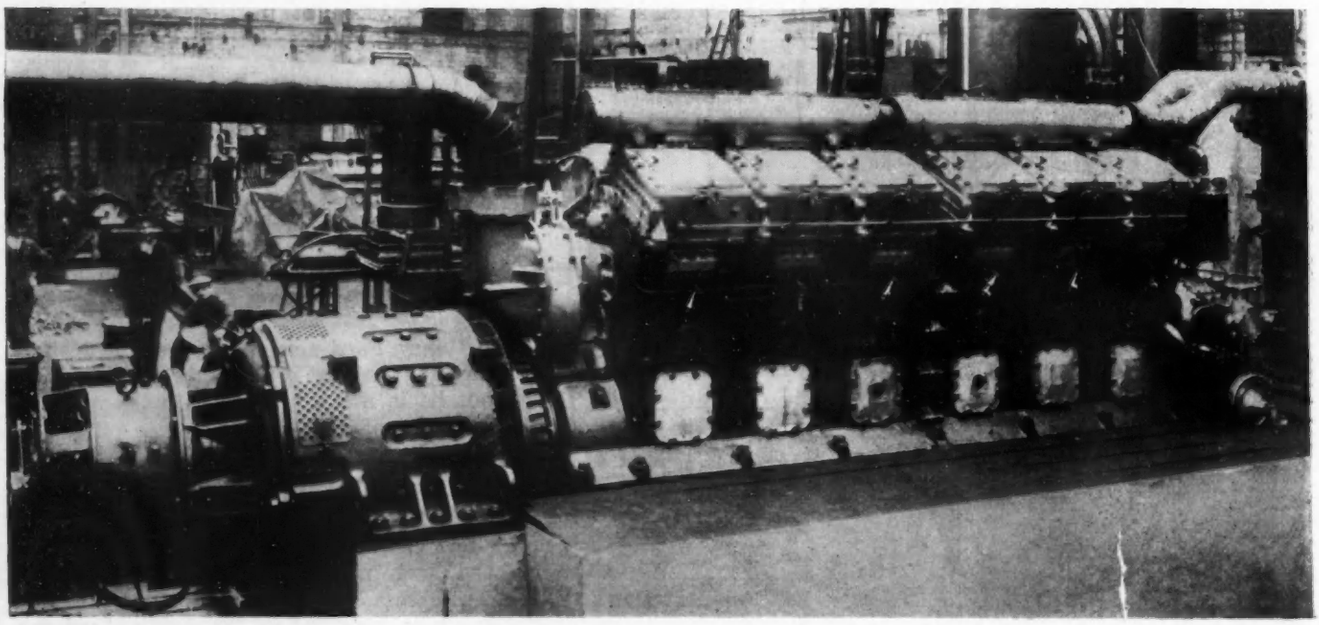


FIG. 24—BEARDMORE ENGINE FITTED WITH SUPERCHARGER

controlled by a bypass valve operated normally by the governor and also pneumatically for quick shut-down. Only the end of injection, and thereby the quantity of fuel injected, is affected by the operation of the bypass valve.

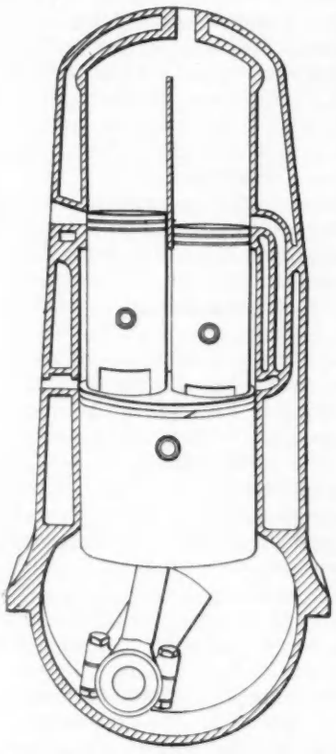


FIG. 25—BONANDER DOUBLE-PISTON TWO-CYCLE ENGINE

The fuel-oil distributor is driven from the camshaft by bevel gears and consists of an intermittent gear which controls the motion of a circular plug in a chamber connected with the discharge of the fuel-pump. In the bottom of this chamber are six equally-spaced holes with connections to the respective cylinder injectors. A spring, augmented by fuel pressure during pump discharge, keeps the distributing plug against this lower face. The gear moves the distributing plug intermittently, and only during the suction stroke of the pump, leaving it with its single hole matched to the desired hole in the face of the chamber during discharge.

Precombustion-Chamber Injection

If the totality of the output in horsepower were a reliable index of the advantages of the fuel-injection system, the Fairbanks-Morse Co., which utilizes precombustion-chamber injection on its standard line of engines as well as on two high-speed models, would no doubt carry away the prize for this system. But the practical solution of any problem is a compromise, and the method of ignition was chosen because much stress is laid upon simplicity in this particular design, a cross-section of which is shown in Fig. 17. The unit is self-contained, since it utilizes the crankcase for scavenging, although at high engine-speed this may be a dear price to pay for simplicity. The fuel-injection valve is only a spring-loaded check-valve, and the fuel-pump is of a variable-stroke type, both simple and compact. Line 17 of Table 1 gives further particulars of the smaller of the two sizes manufactured. This engine is used extensively in small industrial locomotives, also for driving electric generators, pumps, oil-drilling rigs, and for other industrial purposes.

The original work of Brons in Holland and Hvid in this Country, who were the first to substitute gases of partial combustion for air in fuel injection, has led to the development of several modifications of their system of fuel injection. These have prospered especially in Germany, where several different variations are built and where the patent literature on the subject fills books[15]. The Deutz company has retained the original Brons cup in the design shown in Fig. 18, but has substituted pump injection of the fuel for induction by the vacuum created in the engine cylinder. Four and six-cylinder engines are built, conforming to the figures given in line 15 of Table 1.

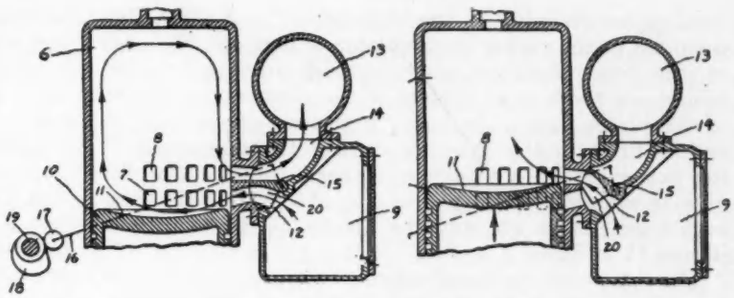


FIG. 26—PATENT DRAWING OF MAGDEBURGER'S SUPERCHARGING CONTROL FOR TWO-CYCLE ENGINES

The Benz company's precombustion-chamber, seen in Fig. 19, has a considerably different design, and it is placed in the center of the cylinder, between the inlet and exhaust valves. The fuel-pump used on the Benz engine is made by the Robert Bosch Co., which anticipated a reduction in the business of building magnetos and developed a very interesting type of fuel-pump and injection valve, to furnish to engine builders as it has furnished magnetos and ignition parts.

Bosch Fuel-Pump an Accessory

A sectioned view of the Bosch pump is shown in Fig. 20. As in several other designs, the suction valve is eliminated and small drilled holes, controlled by the plunger itself, serve as suction ports. A spring-loaded discharge valve of the normal type is fitted, and the metering of the charge is regulated by a helical groove in the plunger. The upward movement of the plunger, which has a constant stroke, forces fuel through the discharge valve up to the moment this helical groove registers with the suction port, when a sudden drop of pressure occurs and further movement of the piston only forces the oil above it back into the suction chamber. Manual rotation of the pump barrel by means of a rack and pinion determines the point in the stroke at which the helical groove will register with the suction port. A truck powered with a six-cylinder M.A.N. engine fitted with Bosch injection made a trial trip from New York City to the Road-Builders' Convention in Cleveland in January, 1928[16].

The Bosch company has also developed its own type of precombustion-chamber Arco engine, the latest design of which is shown in Fig. 21. This type of injection depends upon the high velocity of the air returning from the "outside storage" chamber to atomize and distribute the fuel charge it meets. A 20-b.hp. unit of this type is manufactured and has a fuel consumption of 0.493 lb. per b.hp-hr. at a speed of 1200 r.p.m. A maximum speed of 2500 r.p.m. has been attained with this type of construction, and its suitability for high speed is emphasized.

Another German engine using a unique type of pre-

[15] See Die Patente über Vorkammer-Maschinen, by F. Ernst Bielefeld; and Die Kompressorlose Dieselmaschine, by Ludwig Haasfelder; M. Krayn, Berlin W., 1928.

[16] See *Oil Engine Power*, April, 1928, p. 235.

combustion chamber is the Colo-Diesel[17]. A steel plug mounted in the center of the piston enters into the neck of the precombustion chamber and produces violent turbulence there near the end of the compression stroke of the piston, while the heavy pressures of combustion are confined to the chamber during the beginning of the power stroke, and a flat-top card results. The engine is manufactured in one size of cylinder in numbers from one to six, and the details of one are given in line 11 of Table 1.

The American development of the same type of fuel injection resulted in the new design of Hill engine, illustrated in Fig. 22, which shows the original cup transformed into a cavity through which the fuel spray passes under pressure from the pump. The Hill Diesel Engine Co. manufactures engines having 5 x 7-in. cylinders rated at 12½ b.hp. per cylinder and 6 x 10-in. cylinders rated at 20 b.hp. per cylinder, both at 1000 r.p.m. Two, four and six-cylinder engines are made with cylinders of both sizes. Further particulars are given in lines 18 and 19 of Table 1.

Another outgrowth of the Hvid cup is seen in the Cummins engine[18], in which a low-pressure pump delivers fuel to the injection-plunger cavity, located in the cylinder-head. The injection plunger also draws air from the cylinder and then suddenly forces the heated air and fuel into the cylinder. Apparently some trouble has been encountered from carbon closing the minute openings, and a small turbulence chamber has been incorporated in the piston. This chamber is filled during the compression stroke with air, which later is blown against the atomizer tip, burns up the carbon, assists turbulence and causes better fuel consumption. Several sizes of this engine are built, details of three of which are given in lines 12 to 14 of Table 1.

Supercharging to Reduce Weight

In addition to airless injection of fuel, another and very important means for lowering the weight of the engine is by means of supercharging; that is, by increasing the supply of available air and oxygen in the cylinder so that more fuel can be burned. A blower driven by gears from the crankshaft, as shown on Figs. 23 and 24, has been used by the Beardmore company to increase the output of its 12-cylinder V-type 12 x 12-in. engine at 900 r.p.m. from 1500 to 2000 b.hp. The pressure of the supercharging air is 3.25 lb. per sq. in. In this case, as in all four-cycle engines, the supercharging process is also used to scavenge the cylinder of the residue of combustion gases filling the compression space, with very beneficial effect upon exhaust temperature and fuel consumption, as shown by Büchi[19] on slow-speed engines.

Supercharging aircraft engines by means of exhaust-gas turbo-blowers has been practised in this Country and in France for some time, and in Germany a small automobile was recently fitted with a Lorenzen turbo-blower using air-cooled turbine blades[20].

Supercharging in two-cycle engines can be combined with means for controlling compression, as already noted on the Climax engine, for instance. André C. Attendu built a two-cylinder two-cycle engine[21] for the United States Navy with a valve in the exhaust to accomplish these two purposes. This engine, consisting of two 5½ x 6½-in. cylinders, weighed 500 lb. and developed 85 b.hp. at 1620 r.p.m., thus weighing 4.9 lb. per b.hp. Unfortunately, its fuel consumption could not be made low enough to give the engine the cruising radius required for airship propulsion.

Supercharging is extremely easy to arrange for the Junkers engine; it means only timing the upper piston so that the scavenging ports open later than the exhaust and consequently also stay open after the exhaust ports are closed. Any degree of supercharging can be obtained in this way.

Another high-speed two-cycle engine that has as the chief advantage of its design its ability to supercharge, in the position shown in Fig. 25, is the Bonander engine recently developed at the plant of the American Machine & Foundry Co. in Brooklyn, N. Y. This engine consists of three-cylinder units. Each pair of 2¾ x 7-in. working cylinders is mounted above a single scavenging piston, which is made to serve a similar unit of the engine operating on another crank. A fuel consumption of 0.50 to 0.55 lb. per b.hp-hr. is claimed for this engine, and a weight of 21.2 lb. per b.hp. A supercharge pressure of 12 lb. per sq. in. was used on tests recently made[22].

My own recently patented method of supercharging and control of compression applies to two-cycle engines using a so-called loop system of scavenging, which may be like that used in the large M.A.N. engine or the one that Tardieu has utilized for the Peugeout engine[23], data for which are given in line 26 of Table 1. Fig. 26 shows my control valve, built into the wall between the scavenging and exhaust ports. In the position shown at the left, it permits normal scavenging. After the scavenging ports are closed by the piston, the exhaust ports are used for supercharging. The control can also close the exit of the gases to the exhaust header at any time this may be required by the load and speed.

And finally, the mysterious battle cruiser Ersatz Preussen, with its 50,000-hp. high-speed oil-engine propelling plant, weighing 17.2 lb. per shaft horsepower for all engineering weight, may or may not add much to the progress of this type of engine.

I desire to thank the oil-engine manufacturers and their Washington representatives who have been kind enough to place at my disposal much of the material embodied in this paper.

THE DISCUSSION AT BUFFALO

ANDRÉ C. ATTENDU[24]:—The engine I built for the United States Government was the first to be equipped with an aluminum cylinder-block and steel sleeves. The weight was 4.9 lb. per hp. In cooperation with the Buffalo Gasoline Engine Co., we designed and built another high-speed engine which had a fuel consumption of 0.52 lb. per hp-hr.

A. B. ZAENGLEIN[25]:—How are those small holes drilled in the injectors?

[17] *Oil Engine Power*, August, 1926, p. 486.

[18] See THE JOURNAL, October, 1927, p. 388; and TRANSACTIONS, vol. 22, 1927, part II, p. 59; also S.A.E. JOURNAL, April, 1928, p. 495.

[19] See *Zeitschrift des Vereins Deutscher Ingenieure*, March 31, 1928, p. 421; also *The Shipbuilder*, June, 1928, p. 413.

[20] See *Mechanical Engineering*, March, 1929, p. 220.

[21] See THE JOURNAL, February, 1926, p. 214; and TRANSACTIONS, vol. 21, 1926, part I, p. 207.

[22] See *Automotive Industries*, Feb. 16, 1929, p. 244.

[23] See *Oil Engine Power*, July, 1926, p. 403.

[24] M.S.A.E.—Consulting engineer, Attendu Engines Co., Ltd., Montreal, Canada.

[25] A.S.A.E.—Proprieter, Niagara Auto Repair Shop, Buffalo.

E. C. MAGDEBURGER:—I did not say that they are drilled. The M.A.N. company has patents on a method of casting them around a wire and then pulling out the wire.

CHAIRMAN W. E. JOHN[26]:—We used Resistal steel for the injectors of our Attendu engine and drilled the holes with chromium-plated drills.

MR. ATTENDU:—Mr. Magdeburger failed to mention in his paper the type of fuel used. I understand that most engines today are using 26-deg.-Baumé fuel-oil. The question of oil is an important one, as it has considerable to do with carbonization and other problems.

MR. MAGDEBURGER:—I dealt only with the design; fuel is a subject in itself. The fuel that has been used on some of these high-speed engines looks as if it could not be used on ships. The ideal oil-engine has not arrived as yet; that is why we are interested in following the progress that is being made. Heavy oil is not used in submarine engines or in many slow-speed engines.

A MEMBER:—A matter of equal importance is the lubricating oil. What is the correct viscosity of the lubricating oil for a high-speed Diesel engine?

MR. MAGDEBURGER:—I do not know what the viscosity should be. The Navy uses only one kind of oil in submarine engines. It is called "750," which represents its viscosity at 70 deg. fahr.

CHAIRMAN JOHN:—Observation and study of the Diesel engine show that its lubricating problems are identical with those of the gasoline engine. The requirements depend upon the speed, clearances and bearing area. The oil should have sufficient body to keep the surfaces lubricated, and the problem of heat enters.

E. W. KIMBALL[27]:—Are all submarines Diesel equipped?

MR. MAGDEBURGER:—Yes, with the exception of the British K-26, having a steam engine, which is still in commission. The hot boilers were objectionable when the vessels were submerged. All the heat had to be dissipated inside of the submarine when it submerged.

A VISITOR:—Why was not the Diesel engine used earlier?

MR. MAGDEBURGER:—Because we have only recently been able to get Diesel engines of 3000 hp.

Burning of Oil by the Otto Cycle

A VISITOR:—Have you had any experience with the use of fuel oil in a conventional internal-combustion engine? We are experimenting with it at present in Philadelphia.

MR. MAGDEBURGER:—Many such systems have been proposed and also, I might say, exposed. A few years ago one of the operators at a helium plant in Texas discovered a method. He was brought to Philadelphia and his experiments proved to be a failure, so he went back to Texas. Another attempt was made by a Russian engineer, who created quite a stir in France, but I have heard nothing of him during the last five years. I do not think much of the idea.

A VISITOR:—Are you alluding to the Bussey hot plate?

MR. MAGDEBURGER:—No.

A VISITOR:—We are using oil, preheated 34 to 38-deg.-Baumé, in an ordinary carbureter and swirling it through a centrifugal chamber. We are getting results that are fair, but not equal to those from gasoline. Does fuel oil require constant temperature for good combustion?

MR. MAGDEBURGER:—Many similar attempts have been made. One engineer thought he had a revolutionary idea in using oil in a gas-producer, but his engine was tried and nothing ever developed from it. After the apparent success of the development stage, the experience of the maintenance department determines the practicability of a system.

A MEMBER:—How far are we from the point at which we can place a Diesel engine in the hands of truck operators?

MR. MAGDEBURGER:—The economic side of the question I have not dealt with. The truck to which I referred was operated successfully, but I cannot say whether or not it was economically operated. Mr. Attendu said he operated a car five years ago with a Diesel engine, but he is not doing so today; ask him why not.

CHAIRMAN JOHN:—That M.A.N. truck was brought to this Country two years ago and is still in constant operation by the Robert Bosch Co. in Long Island City. It went through Buffalo during its trip from New York City to Cleveland and back. A. J. Poole, of the Robert Bosch Co., was in our office a few weeks ago and showed me the injectors taken out of that truck.

I should like to start an argument with Mr. Magdeburger about the relative merits of the two-cycle and four-cycle engines for high speed.

MR. MAGDEBURGER:—I do not wish to say that either the two-cycle or the four-cycle engine is the only one. Of 800,000 hp. that has been built, 440,000 hp. is two-cycle and 360,000 is four-cycle; and 195,000 hp. of the two-cycle is in Selzer engines.

Several big motorcoaches in Paris have made cross-country trips on fuel oil and have been reported upon favorably. Probably motorcoaches in this Country will not operate on fuel oil for some time to come, because of the cheap gasoline we have here.

High Mean Effective Pressures

GUSTAF CARVELLI[28]:—Why do Diesel engines operate at such a low mean effective pressure? Many gasoline engines develop mean effective pressures of about 150 lb. per sq. in. or more, without supercharging. A Diesel engine, running with 13:1 or 14:1 compression-ratio, should be able to improve on that.

MR. MAGDEBURGER:—That is the biggest claim that I have ever heard of. I visited a gasoline-engine manufacturer this afternoon who said that his engines develop a brake mean effective pressure of as much as 113 lb. per sq. in. As far as I know, 113 lb. has not been reached in oil engines; 107.5 lb., as indicated in line 4 of Table 1, is the best we can do so far in an airship engine. Our submarine engines are limited to 110 lb. per sq. in. indicated mean effective pressure. The same man who showed me the 113-lb.-m.e.p. engine says he can operate a gasoline engine more cheaply.

CHAIRMAN JOHN:—Most of the Diesel engineers who attack this high-speed problem have not attempted maximum performance. The characteristics of an oil engine are somewhat different from those of a gasoline engine, beause of the degree of heat. The majority

[26] M.S.A.E.—Buffalo Gasoline Motor Co., Buffalo.

[27] M.S.A.E.—Engineer, Vacuum Oil Co., Buffalo.

[28] M.S.A.E.—Assistant motor engineer, Curtiss Aeroplane & Motor Co., Inc., Buffalo.

of Diesel engines are designed to run 24 hr. per day with no garages to call upon in case of trouble. The high-speed oil-engine has been attempted only recently, and no attempt has been made to go into the economics of the question. The automobile engineer is told that his engine is to be so long and so wide, and he must get all the power into that space that he can, and the airplane engine designer is given so many pounds to work to.

What do you think of supercharging, for either the two-cycle or the four-cycle engine?

MR. MAGDEBURGER:—Supercharging may be either to get better fuel-consumption or to reduce the weight per horsepower. The Navy, for instance, is not interested in lower fuel consumption but in increased power for emergencies.

Marine Propeller Drives

A MEMBER:—I have read an article in the *Saturday Evening Post* which said Americans favor the electric drive and Europeans favor gears for ship propellers.

MR. MAGDEBURGER:—We have so far no gear drives in the United States Navy. The Germans use gears in the new battle cruiser for which they claim 50,000 hp. Any one of its engines can be operated by itself.

A MEMBER:—Are the engines reversed as easily as a steam engine? Must they come to a dead stop?

MR. MAGDEBURGER:—The engine must be stopped first, but so must the steam engine. There is no difficulty in reversing Diesel engines.

CHAIRMAN JOHN:—More than 60 per cent of the world's tonnage being built today is being powered by oil engines.

E. T. LARKIN[29]:—I was interested in this development for some time before the Bosch company took it up. I have had a ride in the truck that was mentioned, and it goes. The Acro system apparently is applicable, with very good results, to engines of smaller sizes than most of the oil engines that have been successful, but apparently it is not so good for the larger engines. The fuel efficiency and output are both affected. One thing that seems not to be generally understood is that, while the gasoline engine works most economically at high speed and full power, the oil engine is most efficient at a little less than full power. The gasoline engine has the disadvantage, under light loads, of considerable loss from dilution and lowered compression, while the oil engine uses to better advantage that fuel which is injected and used at light loads.

I am the man whom Mr. Magdeburger quoted as saying that a gasoline engine operates cheaper than an oil engine.

MR. MAGDEBURGER:—How about Mr. Carvelli's 150 lb. m.e.p.?

MR. LARKIN:—I think they get it.

MR. MAGDEBURGER:—Then why do you not get the same?

Economic Comparison of Engines

MR. LARKIN:—We are not operating under the same conditions; we do not use high-test gasoline or other special features. The gasoline engine can be operated economically in this Country, within certain limits. In the first place, the engine costs less to build and can be made with somewhat higher-speed characteristics, and the units coupled to it are naturally smaller. While the fuel itself may be more expensive per horsepower-hour, the cost of the plant is kept down to such a low amount that the standby charges are low. From data in the hands of users of engines of both types, the gasoline engine apparently is the more economical when operated up to 7 hr. per day. The oil engine begins to have a decided advantage for larger sizes or more continuous operation.

MR. MAGDEBURGER:—I am glad that Mr. Larkin explained this. I am an engineer, not an economist. Diesels can be purchased today for $50 per hp.; during the war they cost twice as much. I think these conditions will become more favorable to the Diesel engine as time goes on.

MR. LARKIN:—We have operated engines at full load on 0.5 lb. of fuel per brake-horsepower-hour. I have operated under Government supervision on as little as 0.43 and 0.45 lb., but that is probably a little lower than could be maintained ordinarily in service. Our guarantee is 0.6 lb.

CHAIRMAN JOHN:—I agree with Mr. Magdeburger that the oil engine can be built just as cheaply as the gasoline engine after it has gone through the same period of development. I also think that the two-cycle oil-engine will give greater horsepower per pound of weight than the four-cycle, after it has received the same attention, and that may also be true of the gasoline engine. The supercharger can be used with great success on a two-cycle oil-engine.

MARSDEN WARE[30]:—The combination of supercharging and two-cycle operation in an oil engine has always appeared very interesting. Either this combination or exceedingly high maximum pressure in a four-cycle engine seems necessary to enable the oil engine to compete with the light high-speed high-performance carbureter engine.

Improving Range and Safety

MR. CARVELLI:—One reason for the Diesel engine is that it makes possible a voyage of 12,000 miles without a stop. With coal, refueling would be necessary. I know of one company whose shortest voyage is 7000 miles, and I think that trip is made in 4½ months. It took about a month longer to make the same voyage with a steam engine. The speed has been increased and no stop is required to take on coal. The boiler-room and fuel-room take up considerably more space on the steamship than on ships equipped with Diesel engines, and more merchandise can be carried on the latter. If everybody begins to use fuel oil, it will cost more than gasoline does today. Diesel engines are being used in ships, not because of the reduced cost of the fuel, but because of other items such as I have mentioned.

MR. MAGDEBURGER:—Oil is used for steam engines also, with some saving of space. Diesel engines, however, do not use oil of such low gravity as do steam engines.

CHAIRMAN JOHN:—The real argument in favor of the high-speed oil-engine is the fire hazard. Some very disastrous fires have occurred during the last few years, several of them aboard naval boats. Many large cities—San Francisco, for instance—are restricting the storage of gasoline near public buildings. Much legislation is being passed today requiring the use of oil engines. Such installations alone will keep the Diesel-

[29] M.S.A.E.—Chief engineer, Sterling Engine Co., Buffalo.
[30] M.S.A.E.—Curtiss Aeroplane & Motor Co., Buffalo.

engine manufacturers busy for years. Industrial installations seem to be the biggest factor in the development of the high-speed Diesel-engine; the advantages of its use in the automobile and the airplane are not far behind. Gasoline does produce vapors that explode, and it burns very rapidly. The dirigible is the coming means of travel and I think dirigibles will be equipped with Diesel engines. The same tank capacity will give more mileage than with gasoline engines.

MR. MAGDEBURGER:—I am glad you brought up the question of safety. When a Navy motorboat burns up, there always is a committee to investigate and report. I like to read these reports, because they give the best arguments for getting the money to buy oil engines.

A MEMBER:—What about the use of Diesel engines in industrial powerplants?

Low Fire Hazard of Oil Engines

MR. MAGDEBURGER:—The high-speed oil-engine offers no particular attraction for the power companies. Space and weight are not at a premium in the normal powerplant, but high-speed engines are used in some instances as stand-by units in powerplants. The high-speed engine is needed particularly in cramped quarters; that is why it is used in submarines.

A VISITOR:—I wish to correct any impression that Diesel engines are used only as stand-bys. They are built in this Country primarily to produce power continuously. For instance, a Worthington Diesel engine ran 276 days under full load, was shut down 12 hr. for inspection, and then run for 276 days more. No gasoline engine would do that.

MR. MAGDEBURGER:—Quite true; oil engines will produce power continuously, but also a very serious effort is being made in this Country to sell Diesel engines to carry peak loads for short-time operation.

CHAIRMAN JOHN:—I know of some installations in which the gasoline engine is a stand-by for the Diesel engine. Three such are in Buffalo. I entirely agree with Mr. Larkin that the high-speed gasoline-engine is far more economical than the oil engine when operated for short periods.

Carbon and Fuel-Oils

A MEMBER:—Do you not have considerable trouble from carbon in an oil engine?

MR. MAGDEBURGER:—Carbon formation can result from poor combustion in an oil engine as well as in a gasoline engine, and much trouble has been caused by carbon.

A MEMBER:—Can a variety of fuel oils be used in a high-speed oil-engine?

MR. MAGDEBURGER:—Yes; oils of a very wide range are used; however, submarine engines are operated on a definite fuel. The base is not specified, but a better grade of oil is required than for boilers.

A VISITOR:—The oil burned on submarines is determined by the shape of the hull rather than by the type of engine. Submarines would have to be built entirely differently than they are if they were to use oil that needs to be heated. The Navy specifies grade-B oil just to meet the hull characteristics. Your finger would leave a hole in some kinds of oil at 60 deg. fahr. Such oil has to be heated to be thin enough to flow. Diesel-engine manufacturers are required to build engines to burn the kind of oil that is available where they are to be used. Some engines burn a Mexican crude on which a horse can walk at 60 deg. fahr. Such oil requires a very high temperature.

MR. MAGDEBURGER:—I do not believe you are right about the fuel for submarines. The Navy preheats the oil on battleships, and there is no reason why the oil could not be heated on submarines. Large batteries are available, and steam boilers are used for heating on the larger submarines. I have burned oil in bricks, heated around the exhaust pipe.

A VISITOR:—Where are the fuel tanks on the submarines located?

MR. MAGDEBURGER:—They are carried inside the hull on one type, and outside of it on the later type of submarines.

A VISITOR:—At what temperatures do they operate?

MR. MAGDEBURGER:—At from 32 to 86 deg. fahr. President Harding took a fleet of submarines with him on his trip to Alaska, where very low temperatures were encountered, while the temperature is as high as 86 deg. fahr. in the Gulf of Mexico at some seasons.

DISCUSSION AT PENNSYLVANIA SECTION

H. A. HEGEMAN[31]:—A Mercedes-Benz motor-truck engine is now being tried in one of the electric-drive motorcoaches of the Public Service Corp. of New Jersey, and I believe its operation has been entirely satisfactory. The mileage obtained from fuel oil is about twice as much as from gasoline, at about one-half the cost. Another Mercedes-Benz engine, designed specially for motorcoach service, is on the way from Germany and will be installed in another Public Service motorcoach when it arrives.

E. R. HAILER[32]:—The main characteristics of the Mercedes-Benz oil-engine are light weight and almost constant torque from 6 to 1600 r.p.m. An engine developing 78 hp. at 1600 r.p.m. weighs about 1300 lb. Its over-all dimensions are about the same as those of a gasoline engine of the same output, and the appearance is not much different except that a Bosch fuel-injection pump is used instead of a carbureter and distributor. The charge of air is compressed to about 500 lb. per sq. in., and the fuel is forced in under 800-lb. pressure. A small heating coil is provided in the preignition chamber, to use in starting the engine when it is cold. When the temperature has reached about 50 deg. cent. (122 deg. fahr.) this coil is not required. Many engines of this type have been giving satisfactory service in motor-trucks and motorcoaches in Germany during the last two years.

CHAIRMAN E. B. NEIL[33]:—Did the R-101 actually have a Diesel engine when it was tested? Reports as to that have been conflicting.

MR. MAGDEBURGER:—One of the Navy men who flew across the Atlantic in the Graf Zeppelin visited England and saw the engines of the R-101. Unless they were changed at the last moment, the Beardmore Diesel engines were used.

CHAIRMAN NEIL:—There was trouble with these engines during their tests because of the length of the eight-throw crankshaft, not with anything due to the

[31] Treasurer, National Railway Appliance Co., New York City.

[32] Service department, Mercedes Benz Co., Inc., Long Island City, N. Y.

[33] M.S.A.E.—Director of research, Chilton Class Journal Co., Philadelphia.

Diesel cycle of operation, and I did not know whether or not that trouble had been eliminated.

Metering Small Quantities of Oil

R. W. A. BREWER[34]:—In a paper read recently by A. E. L. Chorlton[35] before the Institution of Automobile Engineers, he called attention to the difficulty of a really effective system of pumping and metering the charge required by cylinders as small as approximately 4 x 6 in. The fuel charge per stroke amounts to the same as a cube of 3.6 mm. (0.142 in.) at full load, or a cube of 2.5 mm. (0.098 in.) at light load.

Mr. Chorlton referred to his flash valve, shown in Fig. 10 of Mr. Magdeburger's paper, as one possible means for measuring fuel in such small volumes, but he does not claim that it is 100-per cent effective. He is emphatic in saying that difficulties like dripping, pulsation of the fuel tubes, lag, and various other things cannot be predetermined by calculation. This statement from a man of his high standing should make us realize fully that the metering of such small charges is an outstanding difficulty at present.

The Packard engine, which I saw at Langley Field, started with remarkable ease. I believe a cartridge was used in one cylinder to start it, and it took up its regular explosions immediately. Is this engine served by a single pump or by several pumps operating from a single cam?

MR. MAGDEBURGER:—The photographs show a small fuel-pump at the center line of each cylinder and a short pipe from the pump to the injector.

D. W. R. MORGAN[36]:—Considerable difficulty was experienced with the engines for the R-101 during the testing period of several years. One of the principal difficulties was securing balance of the propeller and the engine. The engines passed their 200-hr. ground tests and there have been no failures in the air except of a small gasoline engine that is used for starting the Diesel engine.

These engines were originally intended to develop about 700 hp. at about 1000 r.p.m. They are developing about 585 hp. at 900 r.p.m.

Almost every problem in mechanical engineering is a combination of the application of mathematics with common sense and good workmanship. This applies to other things than metering fuel. In spite of that, most of us who are engaged in this Diesel-engine development can give a fairly good demonstration as to how well the quantity of fuel can be controlled.

Considerable progress has been made since the writing of Mr. Chorlton's paper, to which reference has been made, in the use of materials upon which we can rely to maintain very close clearances without being subject to seizure, thus reducing the leakage, which is one of the largest factors that upset any calculations that can be made.

Recent Developments in Metering

Of the many engines offered today, very few employ the flash valve. It is thought that some of the leakage losses and pressure losses can be avoided by eliminating the flash valve and using individual pumps for each engine cylinder.

Engine builders need real encouragement and cooperation, in a development such as that of high-speed oil-engines, from those who will profit by the economies that may result from it. Mention has been made of the fuel-pump that is being furnished by the Bosch company to engine manufacturers. It is a beautiful piece of workmanship, but its workmanship can be duplicated in this Country when such units can be produced here in like quantities.

OTTO NONNENBRUCH[37]—The metering of small quantities of fuel by the flash valve is gaining preference over the metering by a bypass valve, which is fundamentally different. The flash valve is the principle on which the Bosch pump is made, and the accuracy with which the Bosch pump meters out fuel is most surprising. We have made tests in which a Bosch pump was run continuously for several weeks. After two weeks' running, the distribution was just as even as the beginning. It is not impossible that Bosch pumps may become almost as common on Diesel engines as Bosch magnetos once were on gasoline engines.

The highest speed mentioned by Mr. Magdeburger for a Diesel engine is 2500 r.p.m. and the highest commercial speed mentioned by Mr. Hailer, for the Benz, is 1600. What is the limiting speed?

J. BARRAJA-FRAUENFELDER[38]:—I understand that Nitralloy is being used for the plunger and valves of the Bosch pumps. I concur with Mr. Morgan's remark that we can do as well in this Country if quantity production can be secured. The Ex-Cell-O Aircraft & Tool Mfg. Co., for instance, produces plungers, check valves and other accurate parts for various manufacturers of Diesel engines, with at least the same degree of exactness as is found in the Bosch pump. If a concern like that should secure a satisfactory design of pump, embodying correct principles, it could duplicate or perhaps even improve upon the Bosch product. Europeans have had a more fertile field than we have had here for automotive Diesel engines, so the Bosch people have had the chance to acquire and apply experience in the production of fuel-pumps.

High Pressures Accompany High Speed

High speed seems to require high compression and high ignition pressures. All engines that have been run successfully at high speed have had these pressures far higher than are customary in Diesel engines of ordinary types. The ordinary marine or stationary engine has a compression of say 475 to 550 lb. per sq. in. The ignition pressure usually is about 50 to 100 lb. above that, if approximately the true Diesel cycle is followed; but the Mercedes-Benz engine, as I understand from what has been said this evening, has a compression of 800 lb. and an ignition pressure of about 1000 lb. per sq. in. That is conducive to high speed and to burning of very heavy fuel.

I have had experience with Junkers engines which have a compression of about 600 lb. per sq. in. and an ignition pressure of about 950 to 1000 lb. per sq. in., giving a card approaching that of the Otto cycle in appearance and characteristics. I have burned in this engine fuel as low as 18 deg. on the American Petroleum Institute scale. This is quite an achievement for a small high-speed engine. The Junkers people are now marketing an engine of about 2.4-in.

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[34] M.S.A.E.—Consulting engineer, Huntingdon Valley, Pa.

[35] See *Proceedings of the Institution of Automobile Engineers*, vol. 23, p. 502.

[36] Westinghouse Electric & Mfg. Co., South Philadelphia, Pa.

[37] De La Vergne Machine Co., New York City.

[38] J. Barraja-Frauenfelder Co., Philadelphia.

bore and 7.1-in. stroke. It runs at 1000 r.p.m., and develops 8 hp. per cylinder. This engine also has very high compression and ignition pressures, in the neighborhood of 800 lb. per sq. in. for the compression.

MR. MAGDEBURGER:—A number of solid-injection-engine manufacturers ascribe their success to the fact that ignition pressure up to 1000 lb. per sq. in. is conducive to good mixture of the fuel and air charges.

MR. BARRAJA-FRAUENFELDER:—This Junkers engine I have mentioned has a fuel consumption of about 0.32 to 0.33 lb. per hp-hr., which is a real achievement.

MR. HAILER:—There seems to be some misunderstanding. The pressure of 800 lb., actually 840, is that under which fuel is forced into the cylinder. The compression pressure is 550 lb. per sq. in. The development of the Diesel engine, I believe, will be like that of the gasoline engine, by increasing the compression, the speed, the output, and so on.

Equalizing the Distribution

F. L. CREAGER[39]:—Mr. Magdeburger spoke of raising the injection valves to check the load distribution. I know that one company is using pyrometers and thermocouples in the exhausts. What other methods are used for checking distribution?

What is the drain on battery for the electric starting-plug and the starting-motor in the engine described by Mr. Hailer?

MR. MAGDEBURGER:—Assurance of correct distribution is very important, and the means for securing that is to build a pump that will require no serious adjustment for a long time. In case of unavoidable leakages or changes in tappets, there are two ways of checking. The method used on the submarines is to measure the output of each cylinder by means of the generator attached to the engine shaft, by cutting the cylinders out, one at a time. On automotive equipment, the only way is to shut off one of the cylinders and see how the engine sounds. Probably the measurement of exhaust temperature is as reliable as any method for a normal stationary engine, but this requires very good pyrometer equipment which is not easy to maintain.

MR. HAILER:—The injection nozzle on the Mercedes-Benz engine has a spring-loaded needle-valve. The volume of oil that is being sprayed into a cylinder can be regulated by giving this spring more or less tension. Furthermore, feeling of a pin that projects from the cylinder-head shows whether or not the nozzle inside is working. On the exhaust manifold is a plug for each cylinder. In adjusting, this plug is unscrewed, and the color of the exhaust flame shows when the distribution of the fuel is exactly the same in all cylinders.

The heating plugs take not quite 10 amp. each and need to be heated about 10 or 15 sec. on our engine, so the draw is about 60 amp. at 12 volts for 15 sec.

Relative Simplicity of Engines

E. M. NICHOLS[40]:—Simplicity, in comparison with the gasoline engine, is claimed for the Diesel engine. There seems to be no difficulty with the ordinary Diesel engine, but complications arise in adapting it to high-speed automotive purposes, and they are likely to offset its advantages except as to fuel cost. The main difficulty seems to be that of getting the right quantity of fuel to the right spot when it is needed.

MR. MAGDEBURGER:—Did you ever see an automobile mechanic who was not fussing with a carbureter?

CHAIRMAN NEIL:—There is much truth in what Mr. Magdeburger just said. Carbureters have many complicated and very accurately made parts; yet they have been produced in quantity and satisfactorily, in spite of the work that mechanics may have to do on them.

I have seen injection valves that cost $300 each; but there is no reason why the cost of these devices cannot be brought down, as has that of the carbureter, the ignition system and other complicated mechanisms of the motor-car, by large-quantity manufacture. Diesel engines are manufactured now in hundreds, while automobile engines are manufactured in millions; when they are made on an equal basis, I think that the Diesel will fare just as well as the other.

MR. BREWER:—The manufacture of specialized parts plays an important rôle, and that is not really a Diesel-engine manufacturer's job at all. Close cooperation between manufacturers of injection mechanism and manufacturers of Diesel engines is most likely to bring fruitful results in the shortest time.

CHAIRMAN NEIL:—That is what has been done in the automobile field; the specialized jobs have been handed out to those who knew best how to do them.

EDWARD ADAMS RICHARDSON[41]:—It has been suggested that the faster injection-engines run, the higher operating pressures they must employ. This is true when applied to solid-injection, open-cup, and air-injection fuel systems; for these have a common shortcoming in that the fuel is introduced in the form of particles that are large from the chemical standpoint. It is not true as a general statement; for the speed of combustion can be increased at a rate inversely proportional, roughly, to the diameter of the average fuel drop, provided there is reasonable uniformity in the size of the drops. Therefore it should be possible to meet the requirements of any engine speed that is mechanically practicable by developing a fuel system capable of introducing the fuel in a much more finely atomized condition than is at present practicable. The only further requirements are compression pressure sufficiently high to ignite the fuel as fast as introduced and sufficient turbulence to make the air available for the fuel as introduced.

The present tendency is to increase the speed of combustion by early injection. With this early injection, the temperature is materially higher than normal at the end of the stroke. Most of the fuel is present by the end of the stroke, and heated, so that burning is rapidly completed at practically constant volume. The disadvantage of this process is that high maximum pressures are developed in the cylinder. The tendency has been to make the time of injection enough earlier and the maximum pressure enough higher to secure satisfactory operation at the maximum speed of the engine. Whenever engine speeds have been increased, pressures have been raised.

The extremes to which this process has been carried are indicated by an indicator card[42] of the new Packard engine. In this engine, fuel injection begins at 50 deg. before top dead-center, the compression pressure

[39] M.S.A.E.—Process engineer, Victor Talking Machine Co., Camden, N. J.

[40] Manufacturer, Philadelphia.

[41] A.S.A.E.—Assistant to special engineer, Bethlehem Steel Co., Bethlehem, Pa.

[42] See S.A.E. JOURNAL, February, 1929, p. 175.

is 550 lb. and the maximum pressure 1200 lb. per sq. in. for 2000 r.p.m. The weight of this engine, which is about 3 lb. per hp. instead of the 1½ to 2 lb. possible for a carbureter-type engine, is due largely to the high pressures used, for the engine is of remarkably clean design and every effort has been made to employ light-weight construction.

Such data as are available indicate that a maximum pressure of 800 to 900 lb. per sq. in. should be as high as is necessary for the highest-speed racing engine to attain a heat efficiency within 2 per cent of the practical maximum, high mean effective pressure and generally satisfactory performance, provided the fuel system is developed to give finer subdivision of the fuel than is obtainable by pressure injection.

J. P. STEWART[43]:—We regard nothing below 3000 r.p.m. as high speed for the Otto-cycle engine, but we are speaking here of 1200 and 1400 r.p.m. as high speed. A question was asked tonight that has not been answered. I should like to hear an answer, or at least an intelligent guess or prediction, as to what really is the limit in speed for a Diesel engine.

What Limits Diesel-Engine Speed?

MR. MAGDEBURGER:—From what all of the investigators who have gone into the subject have divulged, it seems that the injection of oil is not a limiting factor in the speed of the engine. A German manufacturer who has built a very high-speed engine for naval work recently stated that what limits the speed of a four-cycle engine, either a Diesel engine or a gasoline engine, is the capacity of the valves to fill the cylinders.

As for maximum pressure, Dr. Diesel originally tried to produce a curve with a constant pressure for a certain part of the power stroke; but most of the solid-injection engines operate on what some people call a dual cycle, in which part of the fuel is burned at the dead center and the rest is burned later, so they realize little of the constant pressure. Injection can be controlled to produce any kind of diagram wanted, but apparently most investigators conclude that good fuel-economy goes with high pressures. The relative desirability of maintaining a constant pressure or letting the pressure go up is a matter of discussion right now. Both Dorner and Junkers said, after trying pressures of 1000 and 1200 lb. per sq. in., that high pressures do not materially increase the weight of the engine and do improve the fuel consumption considerably.

From the thermodynamic or theoretical standpoint, the efficiency of any cycle is the same. What gives the Diesel engine an advantage is that it can use higher pressures, which gives it increased efficiency as compared with the Otto-cycle engine. The limiting speeds and pressures may well be left for future development.

A MEMBER:—I should like an answer to the question that has been asked twice tonight: What can we expect in the future of a Diesel engine in revolutions per minute?

J. M. PRATT[44]:—The Mercedes-Benz engine at Newark, N. J., to which Mr. Hegeman referred, develops 70 hp. and has a bore and stroke of 4¼ x 6½ in. The engine we are to receive is 4 x 6 in., with 60 lb. higher compression, runs at 1600 instead of 1400 r.p.m., and develops 78 hp. instead of 70. We also have under test a 100-hp. engine that runs a little faster and has higher compression, which shows that progress is being made.

J. W. WAGNER[45]:—Several single-cylinder test-engines at the National Advisory Committee laboratories have been operated at a speed higher than 2200 r.p.m., with a brake mean effective pressure of more than 100 lb. per sq. in. and a maximum cylinder pressure of less than 800 lb. per sq. in. The fuel consumption is slightly higher than in some of the other engines, a sacrifice which must be made to keep down the maximum cylinder pressure.

A paper on a two-cycle engine was written a short time ago by Dr. Otto Holm, who went into the theoretical possibilities of high speed. This paper has been translated[46] by Prof. P. H. Schweitzer, of Pennsylvania State College. I think it safe to say that the speed is limited, not by anything inherent in the Diesel cycle, but by the ability of the designer. We know that gasoline engines have run at 12,000 r.p.m., but we are not operating them at that speed. The Diesel engine is capable of similar increases in speed; it is the designer's problem to attain the speed at which he wants to operate the engine.

MR. MAGDEBURGER:—According to a newspaper report, Clessie Cummins was driving from his home in Columbus, Ind., to the 1930 New York Automobile Show in an otherwise ordinary motor-car equipped with an engine using ordinary furnace fuel-oil costing 4 cents per gallon. The report stated that it had been driven 626 miles from Columbus to Harrisburg on 23 gal. of fuel.

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[43] M.S.A.E.—Automotive research engineer, Vacuum Oil Co., Paulsboro, N. J.

[44] A.S.A.E.—Vice-President in charge of sales, National Railway Appliance Co., New York City.

[45] Westinghouse Electric & Mfg. Co., South Philadelphia, Pa.

[46] See *Power*, June 19, 1928, p. 1102.

Gaging Airplane-Engine Performance

By J. H. GEISSE[1]

AERONAUTIC MEETING PAPER — *Illustrated with* CHARTS

WHILE virtually all aircraft builders agree in placing reliability as the most important factor in gaging engine performance, from there on agreement is lacking. The author believes that all factors exclusive of reliability can be evaluated so as to provide a good basis for choosing an engine. These factors include durability, which despite the opinion of some aeronautic engineers is not synonymous with reliability; weight per horsepower of the complete powerplant, including radiators and cowling; head resistance; fuel consumption; and first cost.

The effect of changes in engine weight on operating cost are discussed, the text being supplemented by tables showing the effect of increased engine-weight, operating cost and the operation-expense items that are affected. The effect of increasing the engine weight on the durability is gone into, and the statement is made that increasing the weight of a 200-hp. engine from 400 to 494 lb. would be justified provided increases in the time between partial and major overhauls and the total life could be correspondingly increased.

In discussing engine resistance, the author makes the point that the engine manufacturers should be in an excellent position to develop the cowling and select the propeller, and this change would effect a saving to the industry as a whole, since cowling was designed primarily for the engine rather than for the airplane.

In the discussion following the paper one speaker points out that the mean effective pressures will be increased rather than decreased and at the same time the interval between overhauls has been lengthened. The effect of accessibility on the overhaul cost is mentioned by another speaker, while two take exception respectively to the savings claimed by the author and the pay-load that he assumes can be carried. The designing of the cowling is discussed, one speaker arguing that an engine manufacturer would find difficulties in going into production on a cowl that would fit various types of airplane, while another feels that the problem would resolve itself into how far back the engine builder could carry his cowling or how far forward the airplane designer should carry his.

IN CHOOSING the subject, Gaging Airplane-Engine Performance, for this paper I was prompted, not by any feeling that I was particularly qualified to talk on the subject, but by my desire to precipitate a discussion of this most important problem. I feel that an exchange of opinions will be of considerable value to both the airplane and the engine manufacturers.

During a recent trip to a number of aircraft factories I was surprised to find that apparently none had made any analysis of the factors to be considered in gaging an aircraft engine. Naturally, all agree in placing reliability as of first importance, but from there on a lack of agreement that should not exist is apparent. I believe that all factors exclusive of reliability should and can be evaluated with sufficient accuracy to provide a good basis for choice of engines and an excellent guide for the engine manufacturer. The factors to be considered are (*a*) durability, (*b*) weight per horsepower of the complete powerplant, including radiators and cowling, (*c*) head resistance, (*d*) fuel consumption, and (*e*) first cost. None of these is any more important than the others and all should be considered solely on the basis of their effect on total cost of operation per pound of pay-load.

I have included durability, which some will consider as almost synonymous with reliability. They are not synonymous, and engines having equal reliability may vary widely in durability. Wesley L. Smith some time ago gave figures on the comparative reliability of the Liberty engine and our modern engines which indicated that the Liberty engines in his service far exceeded the others from the standpoint of miles flown per forced landing; yet I venture to say that the Liberty engine required more frequent overhauls than did the more modern types. In general, the wear of parts does not affect reliability when knowledge of the rate of wear is available and the parts are replaced accordingly.

Two other items that may be questioned are those of weight per horsepower and head resistance, as ordinarily these are very definitely associated with attainable airplane-performance. Performance is not determined by powerplant weight per horsepower but by total weight per horsepower, or power loading as it is usually termed. An increase in powerplant weight can be compensated for by a decrease in pay-load or fuel load and duplicate airplane-performance obtained. Head resistance is not so easily taken care of; however, if the powerplant weight per effective pound of thrust were available, then head resistance would, to a great extent, be eliminated from consideration. Only in cases of airplanes in which speed is much more important than climb or the reverse would it require consideration other than that involved in cost figures. I shall refer to this again later.

Effect of Increased Engine-Weight on Operation Cost

Leaving out consideration of variation in engine head-resistance as affected by changes in engine form, I have prepared some tables in an effort to evaluate the effect of the factors just enumerated on the total cost of operation. Table 1 lists, in the first column, weight and power data on a representative airplane having an engine weighing 2 lb. per hp. In the second column I have increased the specific weight of the engine to 2.47 lb. and decreased the pay-load to accommodate the heavier engine without changing the total weight of the airplane. To simplify and clarify the analysis of

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TABLE 1—EFFECT OF INCREASED ENGINE-WEIGHT ON OPERATION COST

Specific Engine-Weight, lb. per hp.	2.00	2.47	2.47
Power, b.hp.	200	200	215
Pay-Load, lb.	1,340	1,246	1,340
Engine Weight, lb.	400	494	530
Fuel for 10-Hr. Operation, lb.	750	750	806
Airplane Weight, lb.	2,000	2,000	2,150
Total Weight, lb.	4,490	4,490	4,826
Total Weight per Brake Horsepower, lb.	22.45	22.45	22.45

the effect of the increase in specific engine-weight, I have included a third column for an airplane having the same pay-load as the original design, all values in this column having been obtained by multiplying the data in the second column by the ratio of pay-loads, 1340/1246, or 1.0754. The power loading is thereby maintained the same, giving identical airplane-performance with the same pay-load.

In Table 2 are tabulated those operation-expense items that will be affected by changes in the airplane weight. In this tabulation I have figured an airplane life of 6000 hr. and an engine life of 3000 hr. I have assumed, for sake of simplicity, that the cost will vary directly with weight, although this is probably in error. The increased cost of operation due to the increase in specific engine-weight from 2.00 to 2.47 lb. per hp. is $2.561 during the life of the airplane, or $19.70 for each additional pound of engine weight. This figure can be used in determining how much can be spent on reducing weight only when the reduction does not in any way affect either the endurance or the fuel economy of the engine. When either of these factors is affected the story is entirely different.

Reduced Specific Engine-Weight and Fuel Consumption

First let us consider reduction in specific weight, which has a direct effect on fuel consumption. Such a reduction is obtained by securing high brake mean effective pressures either with or without a geared-up diffuser. To make any analysis we must assume a definite grade of fuel for a base. We are all now well informed as to the limitations imposed by fuels due to detonation. This limitation fixes the compression ratio that can be used for any given volumetric efficiency. I have taken the liberty of reproducing in Fig. 1 a family of curves developed by the Bureau of Standards showing the relations between volumetric efficiency, compression ratio, indicated mean effective pressure and air-cycle efficiency. These curves are based on laboratory tests.

TABLE 2—OPERATION-EXPENSE ITEMS AFFECTED BY CHANGES IN THE SPECIFIC ENGINE-WEIGHT

Specific Engine-Weight, lb. per hp.	2.00	2.47
Costs		
Airplane	$6,000	$6,450
Two Engines	7,200	7,750
Fuel for 6,000-Hr. Operation at $0.04 per lb.	18,000	19,344
Interest on Investment for 5 Years at 6 Per Cent		
Airplane	1,800	1,935
Engine	1,080	1,162
Total	$34,080	$36,641

Using these relationships, I have prepared Table 3 with the compression ratio of the low-volumetric-efficiency engine increased to give the same detonation characteristics as the high-volumetric-efficiency engine with a 5-to-1 ratio. The fuel consumption is also corrected in accordance with the relative air-cycle efficiencies as numerous tests have shown that they will vary in this ratio. Otherwise Table 3 is compiled in the same manner as was Table 1.

Table 3 provides the figures necessary for the compilation of costs in Table 4. The methods of calculation

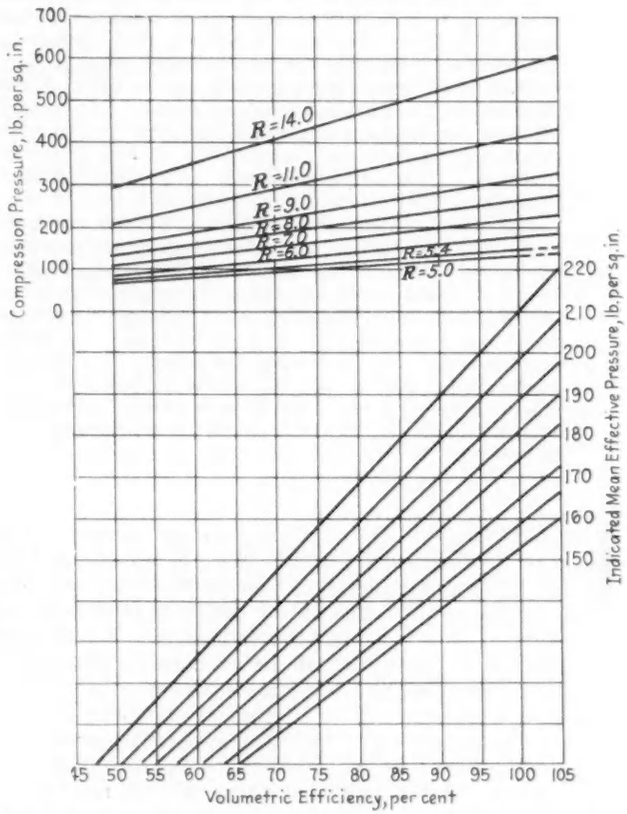

FIG. 1—CHART SHOWING THE RELATION OF THE VOLUMETRIC EFFICIENCY TO INDICATED MEAN EFFECTIVE PRESSURE

In This Chart, Which Was Developed by the Bureau of Standards, the Relations Are as Follows:

Compression Ratio R = (Displacement/Clearance) + 1

Compression Pressure $P_2 = P_1 R^{1.4}$

Otto-Cycle Efficiency $e = 1 - (1/R)^{0.4}$

are identical with those used for Table 2 with the exception of increase in engine cost. In this case I have assumed no change in engine cost, because the cost of the added power required is probably more than offset by the savings attained in the use of a lower mean effective pressure. The results are striking in that they show a decrease in operating cost of $555, in contrast with the former increase of $2,561 for the same change in engine weight per horsepower but with no corresponding improvement in fuel consumption. When consideration is also given to the fact that lower mean effective pressures reduce cooling troubles and increase engine life, these figures possess added significance. The possible magnitude of the latter influence can be gaged somewhat from the following analysis of the value of added weight that increases durability.

Added Weight Increases Durability of Engine

In Table 5 I have regrouped the figures of Table 2 and added figures on cost of overhauls, assuming a major overhaul every 300 hr. and one top overhaul between each two major overhauls. The difference in the total costs remains as before at $2,561, since I have assumed the same overhaul costs for both cases. The operating cost for the heavier engine, which is directly proportional to its durability, is $14,412. To balance costs, we must reduce this figure by $2,561, bringing it down to $11,851. This could be accomplished by an increase in durability in the ratio of $14,412 to $11,851, or 1.215. Expressed in percentage, this calls for an increase in durability of 21.5 per cent to compensate for a weight increase in the engine of 23.5 per cent. In other words, increasing the weight of a 200-hp. engine from 400 to 494 lb. would be justified if the time between top overhauls could be increased from 150 to 183 hr., that between major overhauls from 300 to 366 hr., and the total life from 3000 to 3650 hr. Such increases do not seem to be at all unattainable when it is remembered that this 94 lb. can be utilized entirely for this purpose.

TABLE 3—ENGINE PERFORMANCE AT DIFFERENT VOLUMETRIC EFFICIENCIES

Volumetric Efficiency, per cent	90.0	69.5	69.5
Compression Ratio	5 to 1	6 to 1	6 to 1
Mean Effective Pressure			
Indicated, lb. per sq. in.	138	115	115
Brake, lb. per sq. in.	121	98	98
Air-Cycle Efficiency, per cent	47.5	51.1	51.1
Specific Engine-Weight, lb. per hp.	2.00	2.47	2.47
Power, b.hp.	200	200	206
Weights			
Pay-Load, lb.	1,340	1,300	1,340
Engine, lb.	400	494	512
Fuel for 10-Hr. Operation, lb.	750	696	717
Airplane, lb.	2,000	2,000	2,060
Total, lb.	4.490	4.490	4.629
Per Brake Horsepower, lb.	22.45	22.45	22.45

Now let us reconsider the low-mean-effective-pressure engine. I stated before that low mean effective pressures were conducive to a reduction in cooling problems and an increase in engine life. I do not believe anyone will question this statement. The increase in engine life attained by throttled operation even when the throttling is only to 90 per cent of full power is well known. Comparison of endurance tests at full throttle and at 90 per cent of full power nearly always presents an almost unbelievable difference. Table 5 shows that, for every 1-per cent increase in durability gained by the use of low mean effective pressures, a saving of $144.12 can be added to the initial saving of $555, and all with an increase in airplane and engine weight of 172 lb., an increase in power required of 3 per cent, and a considerable reduction in the ratio of pay-load to total load.

An item I have not mentioned as yet is also worthy of some note. Tests have shown in the case of water-cooled engines that the jacket loss does not increase as the compression ratio is increased. As the power does increase, this means that the heat which must be dissipated from the cylinder-walls per brake horsepower is less with high compression-ratios than with low compression-ratios. Undoubtedly this also holds true with air-cooled engines. A reduction in the heat that must be dissipated from the cylinders can be turned into a reduction in engine drag, which we know is an important item.

TABLE 4—EFFECT OF INCREASED SPECIFIC ENGINE-WEIGHT ON OPERATION COSTS[2]

Specific Engine-Weight, lb. per hp.	2.00	2.47
Costs		
Airplane	$6,000	$6,180
Two Engines	7,200	7,200
Fuel for 6,000-Hr. Operation at $0.04 per lb.	18,000	17,210
Interest on Investment for 5 Years at 6 Per Cent		
Airplane	1,800	1,855
Engine	1,080	1,080
Total	$34,080	$33,525

[2] Based on the data given in Table 3.

Engine Resistance

Reverting to the question of engine resistance, the suggestion was made at the last Aeronautic Meeting of the Society that the pounds of powerplant weight per pound of thrust is of much more importance than the generally accepted figure of pounds of engine weight per brake horsepower. The former takes into consideration the resistance of the engine and its cowling and also the cowling weight. This, of course, would place upon the shoulders of the engine manufacturer the development of the cowling and the choice of the propeller. However, I believe the engine manufacturer to be in an excellent position to do this and that this change would accomplish a saving to the industry as a whole, because the cowling has to be designed more for the engine than for the airplane. The engine manufacturer would have only one cowl to develop for each engine-type, and only slight modifications, if any, would be required to adapt it to different airplanes. Under the present system each airplane manufacturer using the engine has to develop his own cowl, and a point that is not to be overlooked is the fact that, in choosing a new engine, he has to mount the engine, develop a cowl and determine a propeller setting before he can determine whether the new engine will give better or poorer performance than the old.

In conclusion, I desire to repeat that this paper was written primarily to provoke a discussion that will bring out useful information. It has the further object of bringing about the dissemination of this informa-

TABLE 5—OPERATION-EXPENSE AFFECTED BY CHANGES IN SPECIFIC ENGINE-WEIGHT DIVIDED BETWEEN AIRPLANE AND ENGINE

Specific Engine-Weight, lb. per hp.	2.00	2.47
Cost of Airplane	$6,000	$6,450
Interest on Investment for 5 Years at 6 Per Cent	1,800	1,935
Cost of Fuel for 6,000-Hr. Operation at $0.04 per lb.	18,000	19,344
Total Airplane and Fuel Cost	$25,800	$27,729
Cost of Two Engines	$7,200	$7,750
Interest on Investment for 5 Years at 6 Per Cent	1,080	1,162
20 Major Overhauls at $250 Each	5,000	5,000
20 Top Overhauls at $25 Each	500	500
Total Engine Cost	$13,780	$14.412

tion among engine purchasers so that an economically sound method of gaging engines may be evolved. I believe the methods generally used at present are incorrect and that as long as they remain so the engine manufacturer must abide by them and just so long shall we fail to get the utmost out of air travel.

THE DISCUSSION

DR. S. A. MOSS[3]:—I am engaged in making superchargers to increase mean effective pressures. Mr. Geisse proposes to decrease them. As a fact, mean effective pressures are not being decreased but are being increased. What is happening, and what I think will continue to happen, is that we shall get the durability which we all want, and the proper fuel consumption, or proper airplane thrust; in fact, all of the good figures that Mr. Geisse talks about, and at the same time have increased mean effective pressures. Aeronautic engineers are doing this and are improving engines right along. There is a large difference between mean effective pressures now being obtained and those obtained years ago. Mean effective pressures have gone up and durability has also gone up. The number of hours between overhauls now differs greatly from the number a few years ago. Liberty engines formerly had to have a complete overhaul once every 100 hr.; now many engines are given a complete overhaul once every 300 or 400 hr. That has been done without decrease in the mean effective pressure.

Mr. Geisse says that mean effective pressure can be increased with superchargers. I think that this will be done.

ABBOTT A. LANE[4]:—One point was missed on this question; accessibility should be considered along with durability. The cost of overhauling depends upon accessibility and the cost of repair parts. That may be different in the different engines.

I think the cowling should be different for different speeds, because the amount of cooling depends on the air velocity and the quantity of air needed.

On the horsepower question, I think Mr. Geisse should also give consideration to engine speed and propeller efficiency. Two engines may develop the same horsepower at considerably different speeds, and the effect of the propeller efficiency may be different.

J. H. GEISSE:—Most of the purchasers of engines are buying them on the basis of pounds of weight per horsepower. If they continue to do that and absolutely ignore other things, I will put a supercharger on with the rest. We are in business to make money and, if we cannot make it on what we think is an ideal engine, then we shall produce an engine that we can sell. We will try to make the market change its ideas so that we can build the engines that we think are best; I think we can show, actually, that they give better performance in the airplane.

Mr. Lane's point about accessibility is well taken. An engine certainly ought to be accessible, because accessibility affects the overhaul cost. Change in airplane speed may require a change in cowling but so far I have not found any appreciable difference. Even if such a difference should exist, the engine manufacturer, I think, is in a much better position to make changes in his cowling than is the airplane manufacturer. At present I think one of the problems of the engine manufacturer is, as it used to be, to get people to take off some of the cowling because the engines overheat.

I think the engine manufacturer should sell his engine on the basis of pounds per pound of thrust, which takes very definitely into consideration the efficiency of the propeller, the interference of the engine with the propeller, and the shape and the resistance of the engine.

High Compression and Fuel Economy

MAJOR LESLIE MACDILL[5]:—If we compare the throttled operation of an engine of high brake mean effective pressure as we generally operate it and the throttled operation of the oversize engine, will the comparison between the respective fuel economies be in the same ratio?

MR. GEISSE:—You are limiting the compression ratio. You can use a certain amount of compression for the throttled operation but not that same amount for wide-open throttle. The improvement in economy is not confined to wide-open throttle operation.

MAJOR MACDILL:—It therefore seems that if you would throttle down farther you could make a still larger engine and secure better fuel economy in the operating range desired.

MR. GEISSE:—Undoubtedly a limit exists as to how far you can go on volumetric efficiency, as the friction horsepower remains constant. In the calculations I assumed a constant friction horsepower. You can stand a drop in horsepower and still gain in economy. We had one example of that, you may remember, in the Navy where a low-compression engine was used because most operation was at sea level, and the Army used high compression. When the Liberty engine was fixed for the NC-4 to go across the Atlantic, we put in high compression, that is, the Army compression-ratio; but the power was choked down with small chokes to get the best possible combination of power and economy in fuel consumption for that engine.

EDWARD P. WARNER[6]:—I shall not be bold enough to challenge Mr. Geisse on anything that relates to engine design or construction. However, I was interested in some of his calculations of the saving effected in operating cost by decreasing the engine weight and of the increase in engine cost that would be justified, other things being equal, by taking off a pound of weight. Many of these aeronautic problems are pure economics and are subject to this kind of analysis. We try to dispose of them on the basis of conjecture, or supposed past experience that does not apply, or something else, when, if we broke them up into the several parts in which they belong and assigned the most reasonable figure to each one, we could get the answer by arithmetic.

Referring to Table 2, I doubt in the first place if we

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[5] Air Corps, Wright Field; technical adviser, White Weld & Co., New York City.

[6] M.S.A.E.—Editor, *Aviation*, New York City.

can count on 1200 hr. of flying per year to keep the airplane for five years and, secondly, 6 per cent is a rather low rate of interest to figure for aerial operations at present. In the third place, insurance ought to go in as a factor that is proportional to the cost of the airplane and the engine. The saving is now estimated at $2,561. We have not only to buy the engine but to pay interest and insurance on the cost throughout its life. The actual saving would be somewhat under $2,000 on the basis of the present figures if allowance is made for the 30 per cent or so of the engine cost that we are paying as interest during that period in which we are using the engine. The insurance would increase the aggregate outlay still more, and would bring down the saving to something like $1,500.

Concrete Data on Commercial Operation Wanted

WESLEY L. SMITH[7]:—One thing I have observed is that Mr. Geisse's pay-load per brake horsepower is somewhat more than 20 lb. I might say that everyone else would say it is impossible to operate any commercial airline on anything above 12 lb. total load with present airplanes and airports. He has a pay-load of 1340 lb. for 200-hp. engines. We are greatly pleased if we can obtain that figure with 500 hp. with the airplanes and airports we have to use. As long as he is talking in dollars and cents, those are things that are worth considering.

MR. GEISSE:—Mr. Warner and Mr. Smith are saying just exactly what I want them to say. I wish they would not only say that but would write and give us some figures. However, a few statements contradicting or correcting these things will not do us much good. If they will prepare a discussion, sending in figures that they know more about than I do, that will help.

HERBERT G. WINTER[8]:—I take exception to the statement, referring to Table 1 in the paper, that "Power loading is thereby maintained the same, giving identical airplane performance with the same pay-load." It is a different airplane, so we cannot truthfully draw these conclusions.

Comparing the first and second columns in Table 1, we find that it is necessary to re-balance the ship after the changing of 94 lb. from somewhere near the center of gravity to the nose. We have one of two methods, or a combination of these two, to make this change. If we move the engine back, we cramp the pilot, undoubtedly, for the tendency is to have the pilot forward of the front spar for better visibility; and the pilots are usually cramped enough. Another way is to increase the length of the airplane; and, thirdly, to combine these two methods and secure the proper balance. We have then changed the airplane, and the flying characteristics do not necessarily remain the same.

A MEMBER:—I agree with Mr. Geisse that leaving the designing of the cowling up to the engine manufacturers is a step in the right direction. It imposes a new problem on the engine man, I think, but in the long run is the only way that he can control the heating situation, particularly in air-cooled jobs. Is there any adverse reaction to the airplane designers leaving that phase of the situation to the engine men?

B. C. BOULTON[9]:—For an engine manufacturer to go into production on a cowl that would fit various types of airplane would be very difficult because they vary so much. A large cabin airplane and a small cabin airplane might have the same engine, yet the shape of the body immediately behind the engine would differ so greatly that one would hardly feel that the same cowl could possibly suit the engine, keep the appearance that it should have and give the proper streamline. I do not think the same cowling would fit on an engine nacelle, for the same reason.

A MEMBER:—On an air-cooled job we can get just about one combination for installing the exhaust collector-ring and at the same time have a reasonable area for cooling air over the forward part of the engine. Starting out with that combination, we can perhaps carry the cowling back to the present rear portion of the cylinders. From that point forward, we may say the cowling is the same, as a rule in present practice, on the same engine regardless of the airplane. I think the problem of adapting the cowling to the airplane form would resolve itself into how far back the engine manufacturer could carry his cowling or how far forward the airplane designer should work his cowling.

Should Work Out Cowl Designs Jointly

H. K. CUMMINGS[10]:—The cowling design is at best a compromise; it should be a joint affair of the airplane and the engine designers. The history of the development of the National Advisory Committee for Aeronautics cowling was that the aerodynamic engineers started an investigation in the propeller-research tunnel at Langley Field of the effects of cowling and fuselage shape upon the resistance of air-cooled engines, and the powerplant engineers cooperated in a study of engine-cooling characteristics under these conditions.

OTTO HERMANN[11]:—The cowling called the N. A. C. A. cowling was used by me in 1918 and patented by me. It subsequently was used with an air-cooled engine, which was impossible in 1918. It was so far perfected that I showed the cowling in 1925 to Commander Wilson, who was connected with the N. A. C. A. at that time. He copied it and the test proved very successful.

The cowling, in our estimation, should be produced by the engine manufacturer, because he has the facilities to test his engine and to make the cowling to give the highest degree of cooling. The question is whether the airplane manufacturer will pay the price, as that will be a considerable item and add to the cost of the engine. We manufacture today an air-cooled four-cylinder in-line engine of 310-cu. in. displacement, developing 104 hp. at 1900 r.p.m., and we intend to cowl it and sell it as a cowled unit.

LIEUT-COMMANDER JAMES M. SHOEMAKER, U. S. N.[12]:—Will Mr. Geisse tell us the effect of the qualities and cost requirement of a fuel as affected by brake mean effective pressures?

MR. GEISSE:—I cannot answer that question, because I did not go into the analysis of fuels; I started out on the assumption of a standard fuel, which, of course, carries a standard price. My impression is, from figures that I worked out a long time ago, that it hardly pays to use a doped fuel.

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[8] M.S.A.E.—Engineer, Stout Engineering Laboratories, Dearborn, Mich.

[9] Design engineer, Keystone Aircraft Corp., Bristol, Pa.

[10] S.M.S.A.E.—Chief of automotive powerplants section, Bureau of Standards, City of Washington.

[11] President, Century Rotary Motor Corp., Canastota, N. Y.

[12] Head of powerplant design, Bureau of Aeronautics, Navy Department, City of Washington.

Criteria for the Structural Strength of Airplanes

By Alfred S. Niles[1]

Cleveland Aeronautic Meeting Paper

THE NECESSITY and sufficiency of the criteria used by the Aeronautics Division of the Department of Commerce to determine the adequacy of structural strength of airplane designs submitted for approval are being questioned by many airplane designers. Four questions are discussed by the author, who makes no attempt to give complete answers to them but outlines his views to elicit discussion.

Suggestions that have been made for changes in specified design load-factors are divided into one group proposing changes in the method of specifying the design load-factors and another group proposing that the load factors be either larger or smaller than those now required. Difficulties of and objections to carrying out the proposals in the first group are stated. These result largely from the variety of types of airplane and the differences in service and maneuvers to which they are subjected.

No question exists that some of the rules for distribution of the external load should be modified, according to the author, but the real points at issue are which rules should be changed and the specific modifications that should be made. More data on air-pressure distribution are needed, and a very important need that should be satisfied promptly is a structural expert attached to the National Advisory Committee for Aeronautics.

Finally, the author discusses the relative advantages and practicability of using stress analyses versus static tests as a basis of approval of designs. Belief is expressed that approval of a design should be based on a combination of the two methods and that competition will force manufacturers to make static tests but that they will also find it necessary to make complete stress analyses so as to obtain the most economical use of materials.

In discussion, assertion is made that for the last several years the National Advisory Committee for Aeronautics has been developing a group of engineers to determine load distribution by means of flight pressure-distribution investigations and to apply these data to existing design specifications, which is now being done. Another discusser points out that in the load factors on landing-gears the width of tread and height of the center of gravity above the ground are being neglected; also, that tail-surface loading is a function of the maneuverability of the airplane. A third speaker recalls that the Aeronautic Safety Code prepared several years ago took cognizance of airplanes that would be flown acrobatically and those that would be used under conditions that would virtually assure that they would not be flown violently. Moreover, the pilot must be assumed to exercise considerable discretion.

THE DESIGN loads specified by the Department of Commerce are satisfactory in general, though numerous changes should be made in their details. Some of these changes could be made on the basis of existing information but the majority will require the previous collection of additional experimental data. The alternative use of stress analyses and static-test reports to determine the adequacy of a given type of airplane to carry its design loads is proper in the present situation. As more static-test data are accumulated, the rôle of such tests, except as occasional checks, will tend to decrease in importance while that of stress analyses will correspondingly increase.

When the following terms are used in this paper, it is with the meanings given in the following definitions taken from the Air Corps Handbook of Instructions for Airplane Designers.

Basic Load.—The basic loads on an airplane or part are the loads on the airplane or part when the airplane is at rest or in a condition of unaccelerated flight.

Load Factor.—The ratio of some other load to the basic load in which the relative distribution of the forces is the same. This other load may be any of the following: the load applied during some special maneuver, the maximum probable load on the airplane or part, the design load, or the ultimate load. Whenever a load factor is mentioned, the context should show clearly what load is being compared with the basic load.

Factor of Safety.—The ratio of the design load, or the ultimate load, to the maximum probable load. In airplane design, the least factor of safety is usually about 2.0. The term is often used incorrectly in place of Load-Factor.

Many airplane designers are now raising this question: Are the criteria used by the Department of Commerce to determine the adequacy of structural strength in submitted designs necessary and sufficient? This question may be separated into a number of more or less interdependent parts. Four questions, representing four of these parts, which will be discussed briefly in this paper, are:

(1) Should the specified design load-factors be changed?

(2) Should the rules for the distribution of external loads be modified?

(3) Could not the number of loading conditions to be investigated by the designer be reduced?

(4) Should the policy regarding the calling for static-test data be revised?

No attempt will be made to give complete answers to these questions, but the writer will outline his views on these subjects in the hope that they may lead to profitable discussion.

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Objections to Change in Specified Load-Factors

Suggestions of two types for changes in the specified load-factors have been made. Engineers of one group desire to change the present method of specifying the maximum load that must not cause failure, to a method in which the specified load must not produce stresses greater than some set of working stresses lower than the breaking strengths of the materials used. The yield-points, elastic limits, and arbitrary fractions of the ultimate stresses have been suggested for the allowable working-stresses. If any such change were made in the method of specifying the design load-factors, the present figures would have to be changed in proportion unless it were desired to change the required factors of safety. Another group of engineers, satisfied with the present method of specifying design loads, believe that the load-factors specified should be either larger or smaller than those at present required.

The chief, and a sufficient, objection to carrying out the proposals of the first group is the difficulty that would be experienced in checking designs by static test. If the ratio of yield-point to ultimate stress for all materials used in the airplane and for all types of loading (tension, compression, torsion, and so forth) were a constant, and the imposed stress varied in direct proportion to the external load, it would be practicable to use the yield-points as the working stresses, to design for load-factors selected with reference to this method, and to check the design by static tests to destruction. Thus, if the ratio of yield-point to ultimate stress were 0.8, the design could be made to the specified factors and the finished structure should be capable of carrying without failure a load-factor 25 per cent greater than that used in design. Since this ratio of yield-point to ultimate stress is not a constant, and unit stress is not directly proportional to external load for all types of loading, it would be virtually impossible to devise a static test that would be a true check of the design. In a wing designed for a load-factor of 5.0, the failing load for the spars might be 6.0; for the drag struts, 5.8; for the interplane struts, 5.4; and for the interplane wires, 5.2. If the wires actually failed under a load of 5.3, it would be impossible to tell whether the spars and drag struts were of the desired strength. In any actual wing the number of different failing loads to consider would be much greater.

Some advocates of the use of yield-points as working stresses argue that the system is practicable since the design load could be placed on the structure and then removed, and if no permanent set were observed it would prove that the yield-point of no part had been exceeded. This would be true if there were no settlement of the test jig and the deflections were measured with sufficient precision, both being conditions that would be difficult to meet. In practice, settlement of the test jig might lead the observers to report permanent set when there was none. On the other hand, a small but essential part might yield, but with so little effect on the deflections that the resultant permanent set might not be noticed or might be thought to represent only settlement in the jig. In either case the test would fail to give the information desired.

Sometimes it is argued that the specified load should be the maximum probable load and that this load should not stress the structure beyond n per cent of the ultimate stress, the value of n depending on the desired factor of safety. This is not sound, since, when there is any difference, the factor of safety should be the ratio of the load that would cause failure to the maximum probable load, rather than the ratio of the corresponding unit stresses.

If the working stresses were made an arbitrary fraction of the ultimate stresses, we should still have difficulty in checking designs by static tests, but in this case all the trouble would come from the lack of proportionality between internal stress and external load in members subjected to combined bending and compression. To check a design it would be necessary to compute the load-factor at failure for each part of the structure, and these failing loads might vary over a considerable range. This subject has been discussed in Article 173 of Airplane Design, by the writer, in which he shows an example of a strut that has a factor of safety of 16.33 under an axial load of 100 lb. and a lateral load of 1.0 lb. per in., but a factor of safety of only 1.544 under an axial load of 1000 lb. and a lateral load of 10.0 lb. per in. In the case of a wire which had a factor of safety of 16.33 under a given tensile load, the factor under 10 times that load would be 1.633, since in this case the internal unit stress varies in direct proportion to the external load.

The great advantage of the specification of breaking loads is that a static test, even though not carried out with extreme precision, gives a definite answer as to whether the structure conforms to the specification, without the apparent test results being modified by several questionable conversion factors. If the structure holds, it is O.K.; if it does not hold, it should be redesigned. The only question that can come up is whether the material used is above or below average, and this will be present in any case.

Question of a Different Factor of Safety

The question of whether the load factors specified by the Department of Commerce should be changed so as to provide a different factor of safety from those implied by the present figures is much more vital than the one just discussed. The most important data we have on this question are the accelerometer readings made on a number of military airplanes at McCook Field and at Langley Field. A representative selection of these data is given in Table 1, copied from Airplane Design. The original table gave only the recorded load-factors, but in this paper two additional figures have been given for each design. The first figure is the high-angle-of-attack load-factor for the design, as determined from the Department of Commerce rules; and the second is the apparent safety factor, or ratio of this load factor to the maximum recorded. A study of these figures will be of great help in determining what should be done regarding the Department of Commerce specifications.

From the figures of Table 1, it seems that if the airplanes represented had been designed in accordance with the present Department of Commerce rules their factors of safety would have varied from 1.76 down to 0.95. Since most of the readings were taken in maneuvers of considerably more than average severity, it may be assumed that the indicated factor of safety is adequate even though it is as low as 1.50. According to this criterion, the Department rules would be satisfactory for only 8 of the 18 designs represented in the table. It is worthy of note that these 8 are either old designs of large gross weight or with a high figure

of pounds per horsepower. For the pursuit designs, the Department rules would give design load-factors that are obviously dangerously low.

One important class of loads to which an airplane is subjected, but that is not represented in Table 1, are those encountered in flying through bumpy air. We have as yet very few test data on the magnitude of these loads, though some theoretical studies of the subject have been made. Practical experience leads us to believe that, for the larger types, these loads may be as great as or somewhat greater than those encountered in the voluntary maneuvers represented in Table 1, but not as great as the recorded loads for the lighter types of airplane. This lack of knowledge of the true severity of bumps is largely responsible for making 4.5 the minimum load factor in the high-angle-of-attack condition. As can be seen from the table, this does not give an excessive factor of safety against voluntary maneuvers, and it may yet be found insufficient for the involuntary ones.

Aside from the possible exception of the case of flying through extremely bumpy air, the indications of the data in Table 1 are that, while the existing rules give satisfactory design requirements for large or heavily loaded airplanes, they are not adequate for the light, highly powered types. Before accepting this conclusion, however, we must consider the differences in service between military and commercial designs. So far as the large airplanes are concerned, little difference exists between the two classes. Army transports, commercial airliners, bombers, and heavy mailplanes are all subjected to about the same types of maneuver. Therefore it is reasonable to assume that, since the Department rules would produce proper factors of safety for the large military types, they would do the same for large commercial designs. If the factors of safety for the large designs as given in Table 1 were above 2.0, it might be considered practicable to reduce the specified load factors, but as none are that large, and since some of the figures for designs of this class fall below 1.50, such a change could hardly be justified.

For the light, highly powered military designs, the Department loadings are inadequate, but are they also inadequate for the light, highly powered commercial designs? This is an open question the answer to which depends very much on the character of service in which the commercial design is to be used. A plane that is used for sightseeing rides, aerial taxying, or photographic work should not be subjected to strenuous maneuvers, whereas one used for training purposes will be. Thus the Department rules would give adequate factors of safety for designs used in the former types of service but are inadequate for the latter. The difficulty is that the same designs are often used for both classes of service. The Department has tried to solve the problem by specifying load factors that will give factors of safety greater than unity against any but

TABLE 1—LOAD FACTORS RECORDED IN FLIGHT

	Air Speed. Approximate M.P.H.	Airplane Model																	
		JN-6H	PT-1, 180-HP.	PT-1, 150-HP.	TW-5	VE-9	CO-4	XCO-6	XO-2	XO-1	MB-3A	PW-7	PW-8	PW-9	NBS-1	NBS-4	DT	XA-1	T-3
Sharp pull-out	46-65	2.3	2.1	2.1	1.5	1.9	1.7		2.7						1.0	1.5	1.6	1.4	1.6
	66-85	3.3	3.0	2.7	2.2	2.6	2.6	2.0	3.2		2.5	1.6	2.0	2.2	2.0	2.0	2.5	2.1	2.6
	86-105		4.2	3.9	3.2	4.0	3.3	3.4	3.3		3.5	2.7	3.7	3.2	3.1	3.0	2.9	2.9	2.8
	106-125		5.2	4.3	4.7	5.0	4.2	4.2	4.2		5.0	3.9	5.0	3.9					3.3
	126-145							4.4		3.8		5.3	5.8	5.0					
	146-165							4.5		4.1		6.4	7.0	6.4					
	166-185									5.4		7.8							
Gradual pull-out	66-85							1.8											
	86-105	2.1		1.9			4.1	2.0	2.1	2.8					1.5	2.3			
	106-125	1.8	3.9	1.7	4.1	2.25-3.4	4.6	2.3	3.3				4.4		2.0	2.8	1.9	2.7-2.9	1.6
	126-145		4.9	1.9	5.0		5.4	3.0	3.4				4.8	4.6	1.5	3.0	2.6	3.6	2.4
	146-165		5.5		5.7				3.7				5.6	5.5		3.0			2.9
	166-185												7.0	5.8					
	186-205													7.3					
Wide loop		2.3	2.7	1.8	2.3	3.8	3.3	2.2	3.2	3.25	1.6	2.7	3.2	3.0					
Tight loop		3.8	3.6	2.2	3.7	4.4	3.3	3.1	3.8		2.7	6.1	4.25	4.9					
Tail-spin, power off		3.1	2.0	2.0	2.9	2.5	2.4[a]	2.8	3.0		2.0	2.6	3.6	5.8				2.4[a]	
Sharp 180-deg. turn (vertical bank)		1.85	2.8	2.1	3.8	3.2	2.9	2.2	3.6	3.5	3.7	5.7	4.0	4.25	2.9	1.6	2.0	2.5	2.9
Tail-spin, power on		3.3	2.0	1.7	3.3	2.6	3.4[a]	2.7	2.6	3.3	2.6	2.3	4.0	5.1				2.0	
Barrel roll		3.5	4.2	3.2	4.2	3.0[b]	4.1[a]	3.9	3.5	4.5	4.7	7.2	6.0	5.2					
Immelman turn												4.4							
Spiral						1.4						5.5							
Flying on back												1.3							
Mock fight														5.0					
Landing		2.9	2.1	3.0	4.4	2.0	2.0	2.7	1.6	1.6	2.8		4.0	2.3	2.6	1.9	2.6	2.0	2.0
Take-off		3.0	1.9	2.0	2.6	1.8	2.0	2.5	1.7	1.9	2.0		2.9	2.9	2.0	2.0	2.1	1.5	2.0
Maximum design load-factor		6.7	7.2	6.8	7.5	7.4	6.0	6.2	6.3	6.6	8.0	7.4	7.6	7.7	4.9	4.7	4.8	5.0	5.0
Apparent safety factor		1.76	1.31	1.58	1.32	1.48	1.11	1.38	1.50	1.22	1.60	0.95	1.09	1.05	1.58	1.57	5.0	1.39	1.52

[a] Maneuver attempted but could not be accomplished.
[b] Half roll.

the most violent maneuvers, and by prohibiting severe stunting. It provides for requiring designs that are to be used for violent acrobatics to be made for higher load factors, but it considers each case on its merits without promulgating any general rules.

Possibility of Criteria for Different Plane Types

The problem thus boils down to this: Can we devise some criterion for the light, heavily powered designs to separate those which will never be violently maneuvered, and for which the present load factors are adequate, from those which will be violently stunted and for which a higher schedule of loads should be promulgated; and, if we cannot, what should be done?

Under present conditions it seems to the writer to be very difficult to classify the designs. One very promising criterion is that of the type of cockpit, open or closed; but this was tried and found to be unsatisfactory. Some good might be done by considering the type of service, airplanes used for training or sport being required to have the higher factors and allowing those used in other commercial work to be designed for the lower factors. It would be desirable, if this were done, to specify the kinds of work for which the planes designed for the lower factors could be used, and, when the service proposed for a given design was not stated or was hard to classify, to require the use of the higher figures. This is the reverse of the present practice, the use of higher factors being the exception rather than the rule.

The discussion so far has been based on the assumption that the load factors listed in Table 1 are representative of the maximum probable loads for the airplanes in question. While this assumption probably is valid, it should be checked by additional tests. The accelerometer data we have at present are exceedingly scanty compared with what is needed as the basis of a truly scientific list of required design loads. If the requirements are to be based on the types of service for which designs are intended as well as their weights and power loadings, the need for additional data will become even more urgent.

If an airplane is flying at a given velocity, the theoretical maximum load that may be imposed on it by a maneuver not involving an increase in speed is an easily computed factor. At low speeds this theoretical maximum seems to be often reached in jerk pull-ups but it is seldom attained at higher speeds. If we had a true understanding of the factors preventing the theoretical maximum loads from being imposed, we should be able to specify design loads intelligently; and, if some type of airplane were designed for less than the normal factors, we could state the maneuvers that would have to be avoided in its use. For this purpose, additional accelerometer data are essential.

The fact that airplanes of about the same weights and power loadings are used in services involving very different maximum applied load-factors has led to some complaint regarding the use of these two quantities as virtually the sole basis for the specified design load-factor. Aside from the possibility of permitting the design of some light airplanes, limited to specific kinds of service, with lower load factors than would normally be called for, the gross weight and power loading are the most practicable design features on which to base the design load-factors. It must be admitted that they are not wholly satisfactory criteria. The fundamental qualities determining the probable applied load-factors are the ratio of the maximum probable speed of flight to the stalling speed and the quickness with which the angle of attack can be increased. Unfortunately, to determine either of these quantities from the drawings of the airplane is almost impossible; and for administrative purposes the specified load-factor must depend on quantities that can be easily and definitely determined from the drawings. The gross weight and power loading are reasonably satisfactory rough measures of the probable speed range and maneuverability, and probably the best we have for the purpose. They may result in requiring excessive strength in a few designs, but only in those that are well below the average in quality of aerodynamic design; and the industry is not really harmed if the designer of such an airplane is forced to make it a little too heavy. Neither in fact is the designer harmed, as he gains in safety some of the advantage he loses in performance. Where the extra power is added for reserve, as in three-engine designs, the situation is already taken care of by the rule that such airplanes may be assumed to have a power loading of 20 lb. per hp. and thus be designed for the lowest factors allowed for an airplane of the weight in question.

The 20-Per Cent Rule for Connections

Before leaving the subject of load factors, it is desirable to say a few words about the 20-per cent rule. This is the rule that, with a few listed exceptions, requires that all connections between parts of the structure shall be designed to carry a 20-per cent overload. The experience gained in static tests teaches that the weak parts of virtually every airplane structure are the connecting fittings. A main structural member such as a wing spar very rarely fails as a whole. The failures that are most common are those of fittings connecting either separate major members or the elements of a single major member. Even the designs produced by the most experienced engineering organization almost always begin to have fitting failures at between 80 and 100 per cent of the design load-factor. The 20-per cent rule, originally a 15-per cent rule, was devised to encourage the designer to put more material into the fittings and thus prevent having any failures before the design load was reached. If this rule were applied thoroughly, the result would be to make the actual strength from 10 to 20 per cent greater than the design load-factor and to increase the true factors of safety in proportion.

The situation with respect to design load-factors may be summarized as follows: The practice of specifying the minimum allowable breaking loads as design load-factors is better than its alternatives. The use of the gross weight and the power loading as the sole criteria for the determination of the load factors to be used for any given design is generally satisfactory, except that it is possible that a workable scheme might be devised by which light, heavily powered airplanes which will not be subjected to severe maneuvers could be designed for a lower set of factors than those normally called for. The load factors called for by the Department of Commerce are sufficiently high, but not too high, for heavy and lightly powered designs. The load factors for the lighter and more heavily powered designs should be raised so that the severe maneuvers to which these types are subjected, particularly in train-

ing work, will not cause excessive stresses. The 20-per cent rule is useful as a means of insuring that airplanes designed in accordance with it shall develop the full design load-factor, and perhaps a little more. More complete acceleration data from full-scale tests are desirable, particularly from tests made in flying through very bumpy air.

Problem of Changing External-Load Rules

The second main question was whether the rules for the distribution of the external load should be modified. No question really exists that some of the rules should be changed, the real points at issue being in regard to the rules to be modified and the specific changes that should be made. The data on which any changes should be based are primarily pressure-distribution tests and, to a less extent, accelerometer and wind-tunnel tests on complete airfoils and airplane models. The writer made a study of existing pressure-distribution data shortly before leaving Wright Field and reported his findings in Air Corps Information Circular 604, Study of Pressure-Distribution Data. Several of the conclusions drawn from this study are pertinent to the present discussion and will be stated again.

A basic question is whether the agreement between pressure-distribution tests carried out in a wind-tunnel on a small-scale model and those made in flight is sufficiently close to permit the former to be used in place of the latter. Qualitatively, the agreement is sufficiently close, but whether it is sufficiently close quantitatively is open to question. When Circular 604 was written, truly comparable full-scale and model tests were difficult to find. Since that date, the National Advisory Committee for Aeronautics at Langley Field has made pressure-distribution tests on a full-scale Boeing PW-9 in flight and a model PW-9 in the wind-tunnel. The writer has seen no comparisons of the results of the two sets of tests and cannot state definitely whether these tests may have settled the question.

Another question to be settled before detailed changes in the rules can be made is whether the distributions found in tests of monoplane airfoil-models can be assumed to apply equally well to biplane cellules. Present indications are that the monoplane airfoil-model tests are as applicable to biplane as to monoplane cellules provided that the effective decalage is taken into account. Some engineers have visualized biplane-wing interference as a rather chaotic disturbance of the airflow over one wing due to the proximity of the other wing, thus causing a system of load distribution over each wing of the biplane that is dissimilar to that over any monoplane wing. Study of pressure distributions indicates, however, that when two wings are in proximity their chief mutual influence is on each other's true angle of attack. If the wings are geometrically parallel, one usually will have a higher angle of attack than the other, whereas, if they have geometric decalage, the difference in true angles of attack usually will differ from the angle of decalage. If we knew the difference between the true angles of attack for any particular layout of the wings, a quantity we may call the "effective decalage," we could determine from this figure and the distributions on a monoplane wing the distributions on the wings of a biplane.

The existence of effective decalage has some very important bearings on the load distribution on the wings. Not only should the average load per square foot on the two wings be different, but so should the center-of-pressure locations, particularly in the low-angle-of-attack condition. The loading conditions should not be defined by a given percentage of maximum-lift coefficient without stating on which wing this lift coefficient should be acting.

Pressure-distribution tests indicate that in flight the center of pressure may be farther forward and the maximum-lift coefficient considerably larger than is indicated by wind-tunnel tests on airfoils to obtain total forces. Tests on a model PW-9, however, show the same forward centers of pressure as the full-scale tests. As this movement of the center of pressure indicates a much larger load on the front spars than is called for in the Department of Commerce rules, this phenomenon is important.

Pressure-distribution tests indicate also that the load distribution along the span, particularly near the wing tips, is quite different from that specified for use in design. The deviations are specially important near the wing tips and vary greatly with the tip shape and the angle of attack of the airfoil.

More Air-Pressure-Distribution Data Needed

At present, an attempt is made to allow for the uncertainty about the distribution of air pressure over the wing tips by the requirement that the bending moment at the outer strut point be increased by 30 per cent over the value computed for the specified loading. Pressure-distribution tests show that this allowance probably is insufficient. With the distribution along the span varying with both the angle of attack and with the shape of tip used, the total variation is usually much larger than that needed to produce a change in bending moment of only 30 per cent. Since the bending moment over the outer strut point has a most important influence on the size of spar selected, it is important that the true value be known as accurately as possible. This means that a large amount of experimental work is needed to determine the detailed changes that should be made in our present rules.

In the present rules for design, the external loads are distributed so that they will be in equilibrium. To obtain this condition readily, the inertia forces are distributed as though the motion of the airplane were pure translation, though obviously rotation is present in most of the important flying conditions. The National Advisory Committee for Aeronautics is studying the effect of the rotation of the airplane on the load distribution with the aid of accelerometers near the wing tips and tail surfaces, but the results have not yet been incorporated into the design rules.

Though the tests made to date have demonstrated that the rules for load distribution should be modified in many details, they have not progressed sufficiently for many specific changes to be recommended. One reason for this is that no structural expert is attached to the N. A. C. A. who could take the data as they are being obtained and study them from the point of view of the structural designer. A man in such a position could do valuable work, as he could get the data at the source and, after digesting them, could make specific recommendations that would have great weight with the Department of Commerce and the defense services. Also, if there were gaps in the data, he would be in a position to see that they were filled promptly. Lieut.

Lloyd Harrison, in his paper, Some Aircraft Structural Problems, read before the American Society of Mechanical Engineers at St. Louis on May 27, 1929, has recommended the addition of such an engineer to the force at Langley Field, and the writer agrees that this is a step that should be taken as quickly as possible.

Although available data are insufficient or have been insufficiently digested to warrant a complete overhauling of the rules for computing the load distribution, one loading condition that should be revised as soon as possible is the nose-dive condition. The present rule is not only exceedingly arbitrary but also very defective, in that it makes entirely insufficient allowance for variations in the aerodynamic characteristics of different airfoils. It was originally proposed about four years ago by C. J. McCarthy, now of the Chance Vought Corp.; C. N. Monteith, now of the Boeing Airplane Co.; and the writer. At the time its authors regarded it as a temporary makeshift and none of them expected it to last as long as it has lasted. Prof. J. S. Newell, of the Massachusetts Institute of Technology, has suggested that the rule be revised to apply to a condition of dive in which the air speed is four times the stalling speed. While certain details, such as the net lift to be assumed to be acting on the wings, would have to be worked out, the writer believes that the suggestion is fundamentally sound, that the necessary details should be worked out on the basis of present knowledge, and a new rule should be adopted.

Could Reduce Number of Loading Conditions

One of the chief objections to the design rules of the Department of Commerce is their length and the number of loading conditions to be investigated. Some of the criticism has been regarding the number of pages taken up by the rules, due to a belief that rules which are so long must of necessity be hard to follow. This criticism is not often made by engineers familiar with the rules, as they have come to realize that the length is the result of the attempt to make them clear and definite and to cover as many types of design as possible. The chief demand of these engineers is to have them made more definite and to cover more types of design. The more serious criticism is that the rules ask for too many loading conditions. The chief complaint comes in regard to the fuselage and landing-gear, for which seven and four loading conditions respectively are regularly called for, with the possibility of still others.

It is true that this is a large number of loading conditions and some of them are seldom found to be critical. The writer believes that the number of loading conditions could well be reduced, but that the detailed proposals for reduction should be studied very carefully. The first step might be to allow certain loadings to be combined for specified classes of design in the same way that, if the wing spars are not too close together, the Air Corps permits a single rib-loading to be used instead of calling for two loadings. Just what loading condition could be eliminated would be hard to say without considerable further study. This is a question that could be investigated with great profit by the proposed structural engineer that Lieutenant Harrison has suggested for Langley Field. One interesting possibility is a combination of level landing with maximum stabilizer and elevator load. This combination might be worked out in such a way as to eliminate low angle of attack for the fuselage. Another possible combination would be level landing and braked landing, at least for the chassis.

These are merely suggestions; others may be found more suitable. Whatever conditions are dropped or merged, the action should be taken only after study of the probable effects on design. It would also be preferable to limit the combinations to a few types of conventional design until experience proved that they could be applied generally.

Stress Analyses Versus Static Tests

Considerable discussion has arisen as to the relative merits of stress analyses and static tests as the basis of approvals of applications for approved-type certificates. Some engineers complain about the requests of the Department of Commerce for static tests; others, that they are called upon to submit stress analyses and are not allowed to demonstrate the strength of their designs by static tests alone. The writer believes both of these extreme views to be untenable and that the approval of design should be based upon a combination of stress analysis and static test.

The most complete and conclusive evidence that a design is structurally sound and conforms to the design specifications would be static tests of all of the parts under loadings simulating those experienced in all of the conditions of flight and landing that are likely to be critical. However, it would not be desirable to require such extensive tests, on account of the expense involved and the difficulty of making some of them. The better system is to substitute the check of stress analyses for static tests whenever the former are sufficiently reliable and easier to make than the tests.

For some parts and types of construction, tests are relatively easy to make and reliable stress analyses very difficult. A good example is a plywood web rib with lightening holes. To make up half a dozen extra ribs and test them is a simple matter, but to make a stress analysis of such ribs that would be worth the paper it was written on would be most difficult. On the other hand, there are types of construction for which so many static tests have been compared with stress analyses made by relatively simple methods, yet with satisfactory results, that the engineer can safely approve new designs of these structures on the basis of stress analyses alone. The ordinary welded steel-tube fuselage is a good example of these constructions.

The fuselage is a good part of the airplane to have in mind when considering the general problem. If we were to rely entirely on static tests, it would be necessary to make a separate test for each loading condition, or seven in all. By combining stress analysis with static test we are able to adopt a method of computing the strength of the structure and then, by testing, to check the validity of our method of design. It is true that our test may not subject every part of the fuselage to its critical load, but if it subjects the majority of the structure to its critical load and no failure occurs, a reasonable assumption is that the other parts, having been designed by the same methods, will also have their intended strength. Furthermore, the result of the test will indicate whether the method of design used was truly applicable. If a number of similar structures, all designed by the same method of stress analysis, carry the design load, it becomes possible to rely on stress analyses without check by static test for other similar designs. Thus, the first few welded tube fuselages were

static tested. As the test results had been forecast with reasonable accuracy by the stress analyses, the static-test requirement was dropped for that type of fuselage. The first welded fuselages were made of low-carbon steel. When chromium-molybdenum steel began to be employed, with a higher yield-point used in the design computations, some more fuselages were tested to make sure that the use of the higher yield-point was allowable. It proved to be so, and then chromium-molybdenum steel as well as low-carbon steel fuselages began to be approved on the basis of stress analysis alone.

This is a good illustration of how, by comparing the results of static tests with stress-analysis figures, the range of designs for which tests may be omitted can be increased.

Sometimes a new design differs very little from a predecessor. Thus, some of the early mail-planes were observation airplanes slightly modified for the different type of service. Here it would have been quite unnecessary to have asked for a series of static tests to justify the modifications, and the adequacy of the changes was determined satisfactorily by stress analysis.

Stress Analysis Saves Expense and Weight

The writer does not regard it a hardship on the constructor to ask for either a static test or a stress analysis of every main structural part of an airplane. The designer should have such data for his own information before offering his design to the public. Entirely too great a tendency exists to design either by pure guesswork, euphemistically styled "practical experience," or by blind copying, in which calipers take the place of the slide rule, without checking the results by any adequate method. In the end, such design should be backed by tests made either on the design in question or on similar designs. If the test is on the design in question and for the loading under consideration, the test is sufficient. If it is made on the same design but for a different loading, or on a different design, a stress analysis is nothing more than a statement of how the tests indicate that the design under discussion is satisfactory.

Though the regulating authorities may consider the stress analysis in this light, it is of great importance to the designer as a saver of either expense or structural weight. It would be possible to design an airplane without any stress analysis and yet utilize the material put into it with the maximum efficiency. The procedure would be to make a trial design and static-test it. Then a second trial would be made, the parts that failed in the first trial under less than the design load being strengthened and those that appeared to have excessive strength being reduced in size. After many tests, the most efficient possible design might be attained, but the cost would be enormous. By utilizing the results of past tests and making the adjustments necessary to allow for the differences between the structures tested and that being designed, the most efficient design is much more likely to be found and at much less expense. In other words, a stress analysis properly carried out means that past experience is being utilized to save both expense and structural weight.

One aspect of static testing I have left to discuss last. That is the use of a static test as a general check on the design about to go into production. Errors can always creep into a stress analysis and omissions may be made. Therefore, before a design goes into quantity production, one example should be given complete static tests. For the experimental and development work, and for designs of which only a few articles may be constructed, complete tests are not needed unless the construction is unusual. It is my belief that manufacturers will soon be forced by competition to make such tests, but that they will also find it necessary to make complete stress analyses so as to obtain the most economical use of materials.

THE DISCUSSION

JOHN W. CROWLEY, JR.[2]:—With respect to the repetition by Professor Niles of Lieut. Lloyd Harrison's suggestion that a structural engineer be assigned to the staff at Langley Field for the purpose of analyzing the distribution of loads, for the modification of loading rules, it may be stated that for the last few years the National Advisory Committee for Aeronautics has been developing a group of men for that specific purpose. This group has the function of determining the load distribution by means of flight-pressure-distribution investigations, and also of analyzing these data as they apply to the existing design specifications. Up to now the work has been mainly that of obtaining the pressure-distribution data, but the collection of data and study of design rulings has progressed so that the group is now in a position to do exactly as Professor Niles suggests, and in fact has actually done so. In one case a change in the tail-surface loading requirements on pursuit airplanes has been recommended. It is expected that the analysis of both wind-tunnel and flight-pressure-distribution data will continue to be a major function of these men.

With respect to the uncertainty of distribution of air pressures over the wing tip, it should be pointed out that the National Advisory Committee for Aeronautics is now preparing an airplane for tests of a number of different wing tips in flight to determine the necessity for the 30-per cent increased bending moment on the wing-tip position of the wing. It is hoped that, as a result of this investigation, a standard shape of wing tip can be proposed which, by keeping a constant center-of-pressure locus on the wing tip at all angles of attack, may eliminate or reduce the necessity for the increased bending moment.

In regard to the lack of data on loads encountered in bumpy air, an investigation for this purpose is a part of the Flight Research Section program for this year.

RICHARD M. MOCK[3]:—I should like to make two suggestions regarding the load factors used in airplane design, one of which is the side-load landing conditions. We are now neglecting the tread of the landing-gear and the relative distance of the center of gravity from the ground. We are beginning now to have wheel treads of 18 ft. or more, imposing a greater load on the lower

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portion of the structure than that with a considerably narrower tread. The function of the tread is completely neglected with our present requirements. If the airplane is of a low-wing or an amphibian type and the center of the gravity is very low, the landing-gear side loads will be much lower than they would be with the gear in the other position.

The other factor which I have in mind is that at present we are designing the tail surfaces according to loads imposed by the Department of Commerce requirements. These loads applied in tail-surface design are in inverse proportion to the gross weight and neglect completely the fact that the loads imposed on the tail surface are functions of maneuverability of the airplane, as are the loads imposed on the wing.

I have known of instances of airplanes powered with a 200-hp. engine and a certain gross weight having 300-hp. engines substituted without increasing the gross weight of the airplane. The technical and literal interpretation of the Department of Commerce requirements as to loading on the tail indicates loadings exactly the same regardless of the power and maneuverability. It is accepted that the greater power on the same airplane, without changing its weight, made the airplane more maneuverable and this imposed greater loads on the tail surfaces. Of their own accord the individual manufacturers are imposing greater design loads when the power is greater.

Absurd To Design for Improbable Loads

EDWARD P. WARNER[1]:—I find myself in a sort of dual rôle. I tried to give a conscientious rendition of Professor Niles's views as represented in the paper. I have some views of my own which I tried to suppress during the reading.

I am not as pessimistic as Professor Niles appears to be about the use of yield-points as an ultimate basis of design. It seems to me that our present method of design has nothing to recommend it on purely logical grounds except that it does give a check for the static test, which is a good deal, but is after all not the whole story. If we have a true factor of safety of 2, for example, to allow not for unexpected increases of load but for unexpected decreases of perfection of workmanship or flaws in the material, then in a member which is subjected to both bending and compression it is absurd on purely logical grounds to design for a load which is twice as high as any we can ever anticipate is going to be put on the structure. If we are allowing for imperfections, we should work on reduced stress rather than on increased load. Professor Niles has pointed that out with one or two specific examples.

Change of the load factor is a matter on which I have felt strongly ever since the original Department of Commerce handbook came out. The Aeronautic Safety Code was prepared about four years ago and to some extent served as a basis for the Department of Commerce rules when they were first drafted. In it all planes were divided into two classes: those which were going to be flown acrobatically without limit, and those which were to be used under conditions that made it virtually possible to guarantee that they would not be flown violently.

If we are to consider acrobatic flying, we have gone far enough along the road so that we have a clear enough knowledge of what the load on the airplane is coming to, and we must recognize that some limitation must be placed on that kind of flying. Some interesting figures are given in Table 1 in Professor Niles's paper. They are worthy of analysis as showing why I dissent from the statement, essentially, that airplanes cannot reach the maximum theoretical load; that is, that the load factor at low speeds in pulling out of a dive equals the square of the ratio of flight speed to minimum speed but cannot do so at high speeds. I dissent because the tests showed that when the pilot pulled out really abruptly he stayed within about 5 per cent of the theoretical factor all the way up to the highest speed he reached, which was the speed at which the airplane began to give way. The curve was headed northeast indefinitely to higher speeds and higher load-factors, and nothing indicated that he could not go on to a load factor of about 20 if the airplane structure and his bodily structure would have stood it. The maneuverability would have been adequate.

Compare the factors for the MB-3A and the PW-8 in the sharp pull-out from various speeds. In pulling out from about 75 m.p.h. the load factor of the MB-3A is 25 per cent higher than is that of the PW-8. That is natural because the MB-3A had a lighter wing-loading and a lower minimum speed and in the pull-out from any speed the theoretical factor would be higher. The MB-3A factor is a little lower than that of the PW-8 at 100 m.p.h. but at 115 miles it is just the same. If the MB-3A is compared with the PW-7, it will be seen that at the low speed the MB-3A shows a factor 1½ times as high, and at the high speed 1¼ times as high. What is the reason? Obviously, the pilot was uneasy about the strength of the MB-3A when he attained a speed of 120 m.p.h. and was not pulling it out as violently as he could. In the case of the PW-7, the pilot put both hands on the stick and jerked it back with all his strength. That had been done on the PW-9, too, with load factors in excess of 10 having been obtained. That is right on the theoretical curve.

Must Assume Pilot Will Use Discretion

Any airplane that has reasonable maneuverability can have a load of that much if the pilot will pull as hard as he can; but no airplane is going to be designed to withstand that. Therefore, we have to assume that the pilot will use some discretion. I do not see why we should not post on the instrument board of a commercial airplane a sign or warning that the machine—suppose it to have a maximum speed of 130 m.p.h.—is never to be dived at more than 140 m.p.h. under any conditions. Then we should design such an airplane with a factor of safety of a fraction over unity to withstand an abrupt pull-out from that speed, recognizing that if the pilot dives it faster he will get into trouble.

We cannot protect the pilot against himself beyond a certain point. It is impossible to build a small, high-powered airplane that cannot be wrecked by any pilot who sets out to do so. Experience with pursuit planes furnishes evidence of that.

The landing factors in Table 1 are a little misleading, I think. That is off the subject, because they do not concern wing structure but come in the landing-gear and fuselage. These landings were made in the course of the accelerometer tests and by the same pilot. You will see that the worst landing factor for one machine was 2.3 and for another 4.0. I do not pride my-

[1] M.S.A.E.—Editor, *Aviation*, New York City.

self much as a pilot, but am sure I could put a much higher landing-load factor on a machine than that; there is no limit to the results of lack of flying skill. We have to impose an arbitrary specification, and the figure must depend on the service to which the machine is to be put. We also have to recognize that we are going to put out machines with some limitations on their employment.

I am in hearty accord with the suggestion that a structural engineer should be dealing with those research data all the time, receiving them as they come "off the airplane," so to speak, and working in close liaison with the best people so that if a test in progress should suggest other desirable data they can be secured before the test is completed and before the airplane is sent off somewhere else.

Langley Field, as a matter of fact, did start to do structural work when the researches were taken up in 1919, and if you will look back over the old reports you will find several on this matter. One was on calculation of fuselages, one on torsion of wing structure, and so on. That work was, unfortunately, it seems to me, dropped about eight years ago. I hope it will be resumed, both as regards researches in structural theory and especially for the coordination of structural theory with the flight-test data which have proved so invaluable and are the only basis we shall have for continued improvement of load factors.

One other point is that of load factors in bumpy air. That subject should be studied intensively. It is difficult to study because a pilot cannot go out any time he desires and discover bumps; he cannot always find and fly on the edge of a thunderstorm. The tests that have been made have been negative in results. I recall that Lieut. James H. Doolittle once went looking for bumps with an accelerometer on his airplane. He flew over the mountains from Boston to Dayton, Ohio, at a very low altitude but never got a load factor in excess of 1.5, as I recall, although he said that the bumps were fairly severe. His conclusion was that the magnitude of the stresses in rough air is likely to be overestimated by the pilot and the designer. When an airplane hits one of these bumps, it comes as a shock and seems larger than it really is. However, that is not the worst possible condition. I think there is no doubt that just now it would be very difficult to design the structure of a large transport airplane so that it would withstand the worst air conditions. By that I do not mean flying through a tornado or anything like that. The Weather Bureau has records of hailstorms in which the vertical air-velocities amounted to 60 m.p.h. If a pilot could fly out of air that is moving horizontally and pass into air that is ascending vertically at such a velocity, he and the plane would get an awful jolt. Therefore, if we are to design for the worst possible air conditions and not assume that the pilot will have some ability to avoid the worst storms, we shall have to run the stresses away beyond the present limits on the heavier planes as well as on the lighter ones if they are to withstand the most severe maneuvering with which any pilot will be tempted to experiment.

Author Comments on Discussers' Remarks

PROF. A. S. NILES:—Mr. Crowley's statements contain much good news for me. When he left Wright Field, the National Advisory Committee was confining its work on pressure distribution to the collection and compilation of data, and leaving the Army and the Navy to decide what changes should be made in their design rules. The assumption of this responsibility by the Committee is a distinct step forward, and a necessary one if the rules of the Army, the Navy, and the Department of Commerce are to be kept in agreement.

Before leaving Wright Field, I proposed that an extensive study of pressure distribution over various wing-tip shapes should be carried out with the purpose of determining the best shape of tip and the exact pressure distribution over that shape, with the object of eliminating, if possible, the arbitrary 30-per cent increase. At that time the suggestion was turned down, and it is gratifying to learn that it is now being carried out. The inclusion of a study of the accelerations encountered in bumpy air in the program of the Flight Research Section of the Committee is another desirable step, since these two questions, tip loadings and the effect of bumps, are the most important ones still unsolved in the field of external-load determination.

Mr. Mock's criticism of the required tail-loads is decidedly sound, but it seems that this condition will soon be changed. Mr. Roche has recently proposed a new rule for the Army, based upon the tests carried out by the National Advisory Committee, and it seems likely that this rule or one very much like it will soon be generally adopted. I do not know for certain, but believe that Mr. Roche's proposal is an extension of the modified rule for pursuit airplanes mentioned by Mr. Crowley.

Mr. Warner appears to disagree with my ideas regarding the question of using the yield-point or the ultimate strength as the criterion for design. This subject, however, has so many ramifications that it can hardly be covered here, and the conclusions reached by any student of it will be more likely to be determined by the relative weights he gives to the various factors involved than by anything else.

As to the possibility of subjecting a maneuverable airplane to the theoretical load-factor, there probably is less difference of opinion between Mr. Warner and myself than would appear from his remarks. Recent tests have indicated that the theoretical factor can be reached in a violent pull-out from a dive even though the maneuver is made at very high speed, and there is no reason to believe that the same result would not be obtained at even higher speeds than those at which the tests were made. On the other hand, when very high accelerations are encountered, the physiological effects on the pilot are unpleasant, and it is reasonable to believe that the accelerations recorded in the tests are abnormal.

I agree that it would be desirable to post a notice on the instrument board of airplanes stating the maximum allowable speed of dive. This speed could then be used as the basis of design in the Nose-Dive Condition, and the high and low angle of attack load-factors could be brought into relation to the ratio of that speed to the theoretical stalling speed. This would place the design load-factors upon a really rational basis instead of the rather arbitrary one on which they now rest.

The landing load-factors given in Table 1 are not maxima, but represent the results of fairly normal landings and take-offs. The most interesting thing about them is the close agreement between the factors recorded in landings and take-offs, contrary to the general opinion that the landing loads are much the larger.

Application of Engine Governors to Transportation Equipment

By Arthur A. Bull[1]

Transportation Meeting Paper — *Illustrated with* Photographs and Charts

STATING that the two fundamental reasons for the use of governors on motor-vehicles are necessity and desirability, the author mentions further that a very definite acceptance of governor equipment exists on the part of both the manufacturer and the operator. Noting the marked change in the characteristics of powerplants in commercial vehicles that has occurred in recent years, he analyzes the technical considerations that apply to the conditions at present and lists the factors which determine whether the engine, the vehicle, or both the engine and the vehicle shall be governed.

Four essential requirements of a governor are stated and an analysis of the relation of engine speed to road speed is presented.

Present-day governors are divided into two distinct classes: the mechanically driven centrifugal type and the vacuum or velocity type, illustrations and descriptions being given of each. The mechanical construction of each type is also described, the method of making governor calibrations is outlined, the operation of each type is explained and devices for determining governor speed-settings, which also are used as a means for inspection, are illustrated.

In the discussion the vacuum or velocity type of governor was said to have more advantages than it formerly had. The statement was also made that, in the case of an engine which has a maximum torque of 1000 to 1200 r.p.m. and is operated at 2000 r.p.m., a slight reduction of the torque at the higher speeds will not impair the maximum ability of the vehicle. In the case of slower-speed operation, with a maximum torque at aproximately 900 r.p.m. and a governed speed of approximately 1050 r.p.m., close regulation is required to prevent the governor from reducing the maximum torque of the engine.

Certain limitations of benefit derived from governor-equipped engines were mentioned, and the question, Shall we govern engine or road speed? was debated. One discusser pointed out that a governor is not a substitute for driver supervision, since a fleet operator is responsible for the supervision and management of his drivers, but later in this connection a governor was said to be a very able assistant to the supervisor of a motor-vehicle fleet.

Experience with governors was cited, and it was remarked that governors are needed on vehicles equipped with solid tires; but the use of solid tires has been decreasing for several years. In conclusion, it was stated that many of the restrictive legislative acts that have been passed have resulted from the abuse of State laws, and that the need for them would have been eliminated to a large extent if a speed-controlling device had been in universal use.

THE application and use of speed-control governors is old as an art, but the development from the earlier period to the present period of automotive experience forms an interesting review[2]. As applied to present-day transportation equipment, the two fundamental reasons for the use of automatic speed-control devices, or governors, are necessity and desirability. It seems futile to discuss the real necessity for governor equipment in connection with commercial-transportation equipment because of its general acceptance by the industry, which is founded on the principles that have been regarded as fundamental from the early stages of development of the motor-truck. However, the factor of necessity can be considered from two distinct viewpoints, that of

(1) The vehicle builder, who realizes the limitations of the equipment and who must place a limit on the maximum operating speed to assure satisfactory operation and freedom from trouble; and that of

(2) The engine builder, who supplies powerplants for the vehicle builders but has little to say about the axle ratios to be used or the relative engine and road speeds. Recognizing from experience that most of his troubles and complaints arise from excessive speeds, he must set a safe limit of speed on his engine and strongly urge his customer to apply suitable governing; or he must make a governor a standard part of his powerplant.

In both of the foregoing situations, the governed speed may be the maximum that is consistent with the engineering factors involved. The fleet operators' requirements generally will be for lower governed speeds than those set by the manufacturer, occasioned by the different operating conditions in different territories, the problem of maintenance costs, the transportation of merchandise that may be depreciated by excessive shocks, or in following out the desire to observe local traffic laws and the general interest of "safety-first" operations.

The desirability factor is not usually considered, yet there is a distinct measure of operating convenience and ease of handling with governor control which the driver of the vehicle learns to appreciate, and which adds to the benefits arising from the elimination of abuse through overspeeding beyond safe limits either

[1] M.S.A.E.—President and general manager, Handy Governor Corp., Detroit.

[2] See S.A.E. Transactions, vol. 11, part 1, p. 333.

intentionally or unconsciously. Moreover, with governor control, economies in fuel and oil costs per ton-mile show as definite results from more uniform operation.

Acceptance of Governor Equipment

A very definite acceptance of governor equipment exists, by both the manufacturer and the operator. Most vehicles of more than 1½-ton capacity are equipped with governors at the factory. Vehicles of less than 1½-ton capacity are not generally provided with governors as standard equipment, largely because of the reluctance to add anything to the vehicle that will increase its cost but will not, in the opinion of the sales department, necessarily contribute to its salability. Yet these same vehicles, which, for the most part, are assembled from passenger-car engines and components, become subject to far greater abuse in transportation service and are less able to withstand the extra stresses involved in both engine and chassis that result from speed and overload than are the heavy-duty vehicles which are built primarily for such service. A large proportion of these vehicles become governor-equipped in service, as nearly all large-scale fleet-operators obtain governor equipment for these vehicles and apply it before the vehicles are put into service. Some of the manufacturers, knowing the inevitable necessity for such equipment and yet reluctant to absorb the cost, compromise to the extent of offering it optionally, or as an extra, when specified.

Opposition to governor equipment, so far as factory adoption is concerned, frequently will arise from the sales department. The opinion of the sales department as to necessity is regulated by the field demand without appreciating the situation as one that must originate in its own plant if a vehicle that is protected against abuse is to be placed in the users' hands, and is to be one that will give more continuous and satisfactory service, which inevitably results in the establishment of prestige and good-will.

Technical Considerations

A marked change in the characteristics of power-plants in commercial vehicles has occurred in recent years. Most engines are now of the high-speed type, with six cylinders instead of four, and are running and carrying their horsepower up to and above an engine speed of 3000 r.p.m. The employment of these engines has been brought about by the development of the passenger-car engine and by the requirements for increased flexibility and speed in commercial service. Increased horsepower accompanies the higher rates of speed, as is emphasized by the comparative power-curves shown in Fig. 1; but the increased power and speed will not show a proportionate increase in road speed. The limit of top speed in high gear is regulated to a large extent by the tractive resistance of the vehicle, and the top limit of speed occurs when the tractive resistance equals the tractive effort, the product of engine torque and gear ratio. The high horsepower-output at the higher speeds does not necessarily convey any better pulling ability at the lower speeds unless the engine torque and the gear ratio are

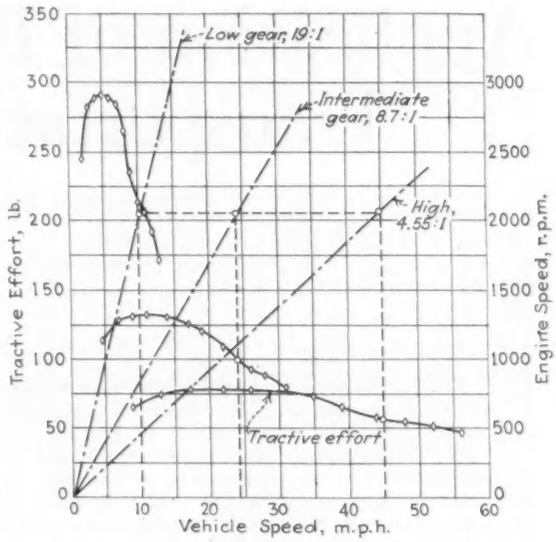


FIG. 3—CURVES SHOWING THE TRACTIVE ABILITY AND RELATIVE ENGINE-SPEEDS AND ROAD-SPEEDS WITH DIFFERENT GEAR-RATIOS

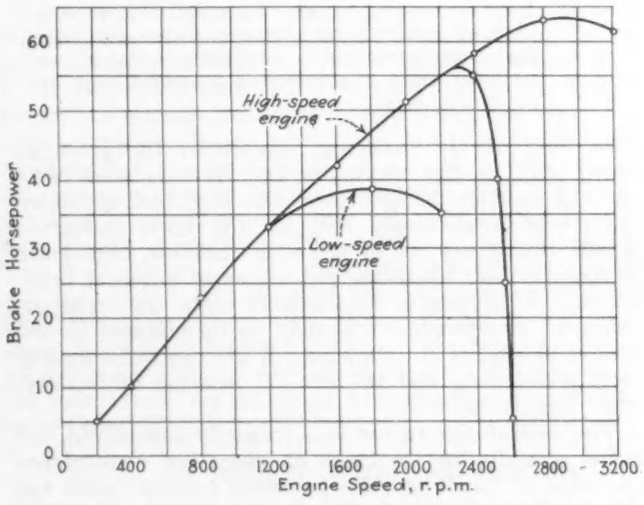


FIG. 1—COMPARATIVE HORSEPOWER CURVES FOR HIGH-SPEED AND FOR LOW-SPEED ENGINES WHEN GOVERNOR CONTROLLED
Increased Horsepower Accompanies the Higher Rates of Speed

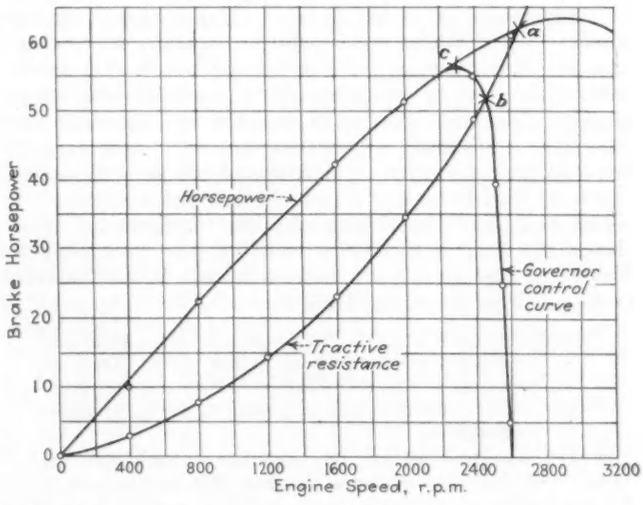


FIG. 2—POWER AND TRACTIVE-RESISTANCE CURVES, WITH AN HYPOTHETICAL GOVERNOR-CONTROL CURVE SUPERIMPOSED ON THE POWER CURVE

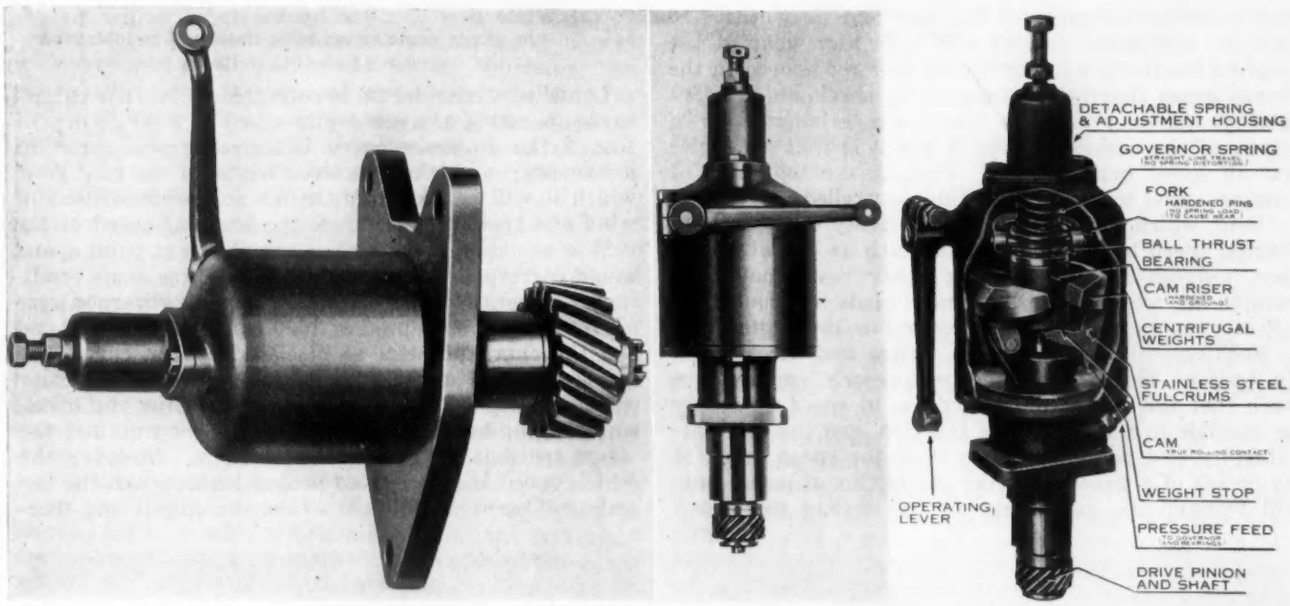


FIG. 4—MECHANICALLY-DRIVEN CENTRIFUGAL-TYPE GOVERNORS
(Left) "Servo" Horizontal Type. (Center) Vertical Type. (Right) Sectional View of Vertical Type, Showing Internal Mechanism

proportioned and arranged to increase the power at the rear wheels of the vehicle.

As to the safe limit of engine speed, in general the maximum engine-speed must be within the limit for which the engine was developed and may be determined by several factors such as bearing loads, valve operation, valve temperatures and oil temperatures, the safe limit being set at that speed at which the engine will operate continuously without overload or failure.

Although engines differ, we may take as an average a maximum speed of 2600 r.p m. and observe how the speed settings, determined from the foregoing factors, compare with the possible top-limit speed of the vehicle and the other factors of performance. Fig. 2 shows normal power and tractive-resistance curves of a six-cylinder engine and, super-imposed thereon, the hypothetical governor-control curve of the vehicle, which would indicate a maximum top speed equivalent to 2600 r.p.m. of the engine. Thus it might be said that, inherently, the engine speed will be self-controlled when operating in high gear, which would be true were it not for the factors of variability in load and grade that necessitate a definite cut-off point in the engine speed.

The most important necessity for control of engine speeds arises when operating in the lower gears. Fig. 3 shows the tractive ability and relative engine-speeds and road speeds with different gear-ratios. The maximum tractive ability in the lower gears occurs at a point corresponding with the maximum torque-output of the engine; it is possible, therefore, assuming that the tractive resistance were less than the maximum torque-output, for the engine to be run at unlimited speeds.

Governing the Engine, the Vehicle, or Both

From a study of the charts in Figs. 1 to 3, it seems obvious that speed control must of necessity be applied to the engine, the only exception being in the event that the top road-speed, as limited by operating conditions or legal speed-limits, would need to be fixed at an engine speed lower than that for the maximum-torque effort of the engine which, from Fig. 3, obviously would retard the operating efficiency of the vehicle in the lower gears. This sometimes occurs in export vehicles for some countries in which the top-speed legal-limit is very low; for example, in light vehicles of 2-ton capacity the speed is as low as 16 m.p.h. in high gear.

If the conventional gear-ratios are used in the transmission, both the operating speed in the lower gears and the tractive ability necessarily are reduced to a point that seriously interferes with the operation of the vehicle. This seems to suggest the use of a control device operable from the transmission to keep the road speed constant, with the engine speed proportionally variable; however, such a control places no limit on engine speed beyond the first step in the transmission. A better method is

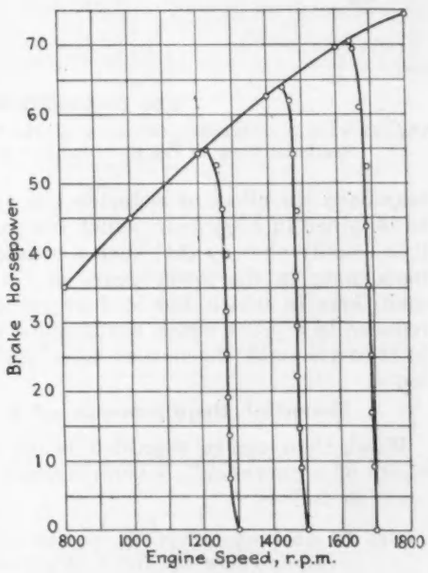


FIG. 5—GOVERNOR-CONTROL CURVES FROM A CENTRIFUGAL-TYPE GOVERNOR
The Brake-Horsepower and Governor Curves Shown Are for a Six-Cylinder Engine of 380-Cu. In. Piston-Displacement

the judicious selection of the axle and gear ratios to get the maximum tractive ability in high gear at the highest engine-speed, and the highest road-speed in the lower gears that is consistent with maximum tractive ability. Another obvious conclusion arising from a study of the curves in Figs. 2 and 3 is that a definite cut-off speed must be used; that is, the top limit of engine speed must be definitely controlled, regardless of load, which indicates the impossibility of controlling engine speed by any fixed means such as by valve timing, reduced manifold-size or other restrictions, attempts at which are sometimes made ostensibly to effect some measure of speed control on the engine.

Requirements for maximum torque and acceleration in present motor-truck and motorcoach engines are such that the engine must increase in speed as nearly as possible to a straight-line function, and the only satisfactory and possible way to limit the speed at all is by means of a governor. Any restriction of power output through the use of any of the devices mentioned

(4) While ease of adjusting the speed setting must be given some thought, it must not be obtained at the expense of the other items mentioned.

Let us now consider an hypothethical governor-control curve operating at a set engine-speed of 2600 r.p.m. In Fig. 2 the governor curve is superimposed upon the horsepower and the tractive-resistance curves, from which it will be seen that, under normal conditions of wind and tractive resistance, the top road-speed of the vehicle would be at 2600 r.p.m., as shown at point *a*, and would correspond to 45 m.p.h. Under these same conditions of operation and, assuming that the governor were set for a maximum speed of 2600 r.p.m. with no load and had the characteristics as disclosed by the curve, the horsepower output of the engine with the governor would correspond with the point *c*, reducing the maximum output by 6 hp., as between 2600 r.p.m. and the cut-off speed of the governor, 2250 r.p.m. However, the vehicle speed is not reduced proportionately and the top limit will occur at point *b*, where the output and trac-

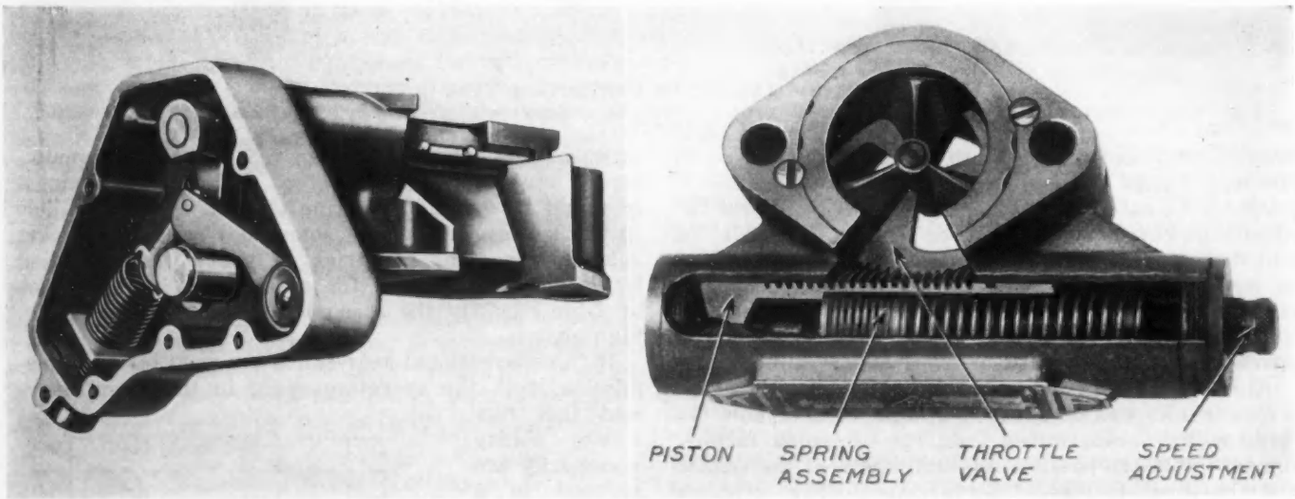


FIG. 6—CONSTRUCTION OF MIXTURE-FLOW-VELOCITY TYPES OF GOVERNOR

The View of the "Handy" Governor at the Left Shows Arrangement of the Parts, the Spring and the Cam. At the Right Is a Sectional View of the K-P Vacuum-Type Governor, Including the Venturi Valve, the Piston and the Spring Assembly

may have the effect of reducing the maximum that can be obtained in high gear, which is shown in Fig. 2; but it is equally obvious that such a means would be totally inadequate in the lower gears or, in fact, under any conditions in which the load or tractive resistance is reduced to a point which would allow the engine speeds to increase until the output coincides with such resistance.

Essential Requirements of a Governor

What, then, can be regarded as the essential requirements of a governor? I quote from a prominent engineer, as follows:

(1) It must not affect the power of the engine at speeds below the full-load governed speed.

(2) The speed difference between full load and no load should be held to the minimum; but, at the same time, this difference should not be so small that hunting or surging will occur.

(3) In the speed intervals between maximum load and no load, running must be perfectly stable; that is, there must be no "hunting."

tive resistance coincide, equal to 2430 r.p.m. or 42 m.p.h.

The assumption is made that the tractive resistance of the vehicle with full load would coincide with point *b* in Fig. 2, but, in fact, the top-limit road-speed might be any place between the cut-off point *c*, represented by 2250 r.p.m., and the no-load speed of 2600 r.p.m., depending upon whether the vehicle were climbing or going down a grade. Such a variation would constitute the maximum limits of operating speed of the vehicle that was under the control of the governor, which, in any event, would never exceed the safe maximum speed of 2600 r.p.m.

The accelerative ability of the vehicle is controlled by the excess of power-output over the tractive resistance, represented by the area between the two curves and, with a governor having the characteristics shown, this accelerative ability is not disturbed up to the governed speed because the governor valve is open until the cut-off point is reached. Table 1 gives actual records of acceleration tests with and without a governor, for the purpose of comparison.

Relation of Engine Speed to Road Speed

The recommended maximum engine-speed varies with the piston displacement; as an indicator, the recommendations of a prominent engine builder for speeds of a six-cylinder engine of given piston displacement at full load are as follows, and the maximum speeds at no load should not exceed 10 per cent more than those stated.

Piston Displacement, Cu. In.	Engine Speed, R.P.M.
420	1,800
380	2,000
340	2,200
312	2,300

It is further recommended by this engine builder that any vehicle in which the ratio of engine speed in number of revolutions per minute and vehicle speed in miles per hour is greater than 50 to 1 should be governed, this being equivalent to a gear ratio of 5:1 with 34-in. tires. Therefore, if the desired road speed is known, the axle ratio is determined from the maximum engine-speed and, to produce the necessary top road-speed, the engine displacement must be sufficient to produce, with the axle ratio established, a tractive ability at the wheel equal to the resistance at the required road speed.

Present Types of Governor

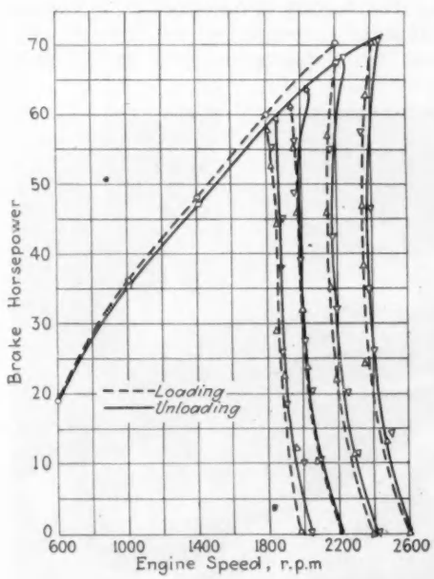
The surviving types of governor are all in the general category of mixture-throttling variety in two distinct classes: the mechanically driven centrifugal type and the mixture-flow—that is, vacuum or velocity—type. The models shown in Fig. 4 are representative of the mechanically driven centrifugal group, that at the left being the "servo" horizontal type which is driven from the timing gears; the vertical type is illustrated at the right. Special provision must be made for driving these governors, and a separate throttle-control body is used between the carbureter and the manifold, the connections between the governor and throttle being enclosed to avoid tampering. At the extreme right in Fig. 4 is a sectional view of the "servo"-type governor, the interior construction being typical of this type except for the development of features to provide extreme accuracy of regulation and uniformity in operation. An average power-curve of a mechanically operated centrifugal governor which has suitable road characteristics and a reasonable amount of the adjustability, together with stability, is shown in Fig. 5.

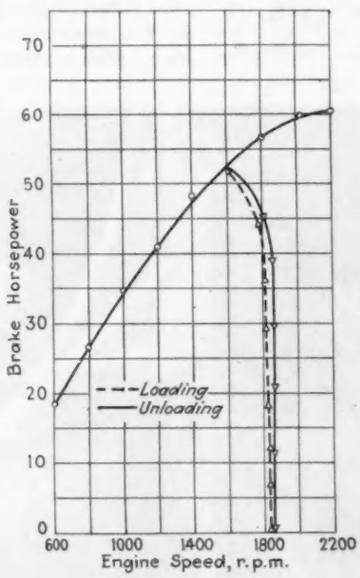
TABLE 1—ACCELERATION TEST MADE WITH A GOVERNOR SPEED-SETTING OF 44 M.P.H., TIRES OF 32-IN. DIAMETER, AN AXLE RATIO OF 6.14 TO 1, AND A GROSS LOAD OF 11,700 LB.

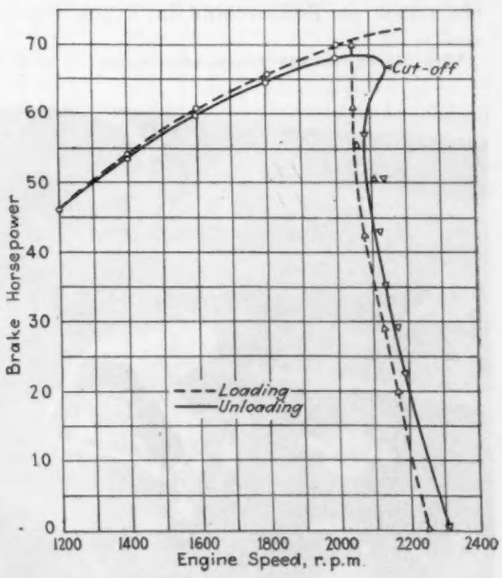
Acceleration, M.P.H.	Direction	Time, Sec.	Average Time, Sec.
Without Governor: 10 to 41	North	57	55.5
	South	54	
10 to 40	North	52	50.0
	South	48	
With Governor: 10 to 41	North	48.5	52.7
	South	57.0	
10 to 40	North	47.0	50.0
	South	53.0	

The mixture-flow-velocity type of governor, shown at the left in Fig. 6, and the vacuum type shown at the right, are now in most general use as standard equipment for all types of truck and transportation equipment. Figs. 7 and 8 show characteristic power-curves taken from a mixture-flow governor of the velocity type, and Fig. 9 shows a characteristic power-curve from a vacuum-type governor. The curves indicate the range of adjustability. The points on the curves are the load applications applied through the range from no load to full load and indicate the stability control.

The velocity-type governor-unit is installed between the carbureter and the manifold, a typical installation being shown at the left in Fig. 10; and an installation







CHARACTERISTIC BRAKE-HORSEPOWER AND GOVERNOR-CONTROL CURVES

Fig. 7—Curves Taken from a Velocity-Type Mixture-Flow Governor on a 3⅝ x 5-In. Six-Cylinder Engine of 310-Cu. In. Piston-Displacement

Fig. 8—Curves from a Velocity-Type Mixture-Flow Governor on a 4¼ x 5-In. Four-Cylinder Engine of 285-Cu. In. Piston-Displacement

Fig. 9—Curves from a K-P Vacuum-Type Governor on a Six-Cylinder Engine of 340-Cu. In. Piston-Displacement

of the K-P vacuum-type governor is shown at the right. The performance of the mixture-flow type of governor in its present state of development is in marked contrast to that of the earlier types used, against which severe criticism was directed because of their poor performance; usually, they would cut in at very low speeds and seriously impair the operating efficiency of the vehicle.

The preference for the manifold type of governor has resulted, in a measure, from its adaptability, because it makes unnecessary any provision for the driving of mechanical devices. This is particularly important in commercial vehicles in which the powerplants are adaptations of passenger-car equipment. However, in itself, this applicability would not have brought about its almost universal acceptance were it not for the fact that its performance is satisfactory and comparable with the best that can be obtained from mechanically driven devices. It has the further advantage that its range of adjustability usually is greater than that which can be satisfactorily obtained from the centrifugal-type governor unless it is of special form.

Experience has indicated that, for maximum stability and speed control, the governor curve should have a minimum difference of 5 to 8 per cent between full-load and no-load speeds; and satisfactory results, so far as road operation is concerned, will be evident even though the difference between full load and no load is 15 per cent. This permissible range in the governor curve can logically be used when operating at speeds in excess of 2000 r.p.m., in contrast to the range that would be required if the engine were operated at a speed of 1000 r.p.m., as was common practice in heavy-duty design many years ago.

It is significant to indicate that, in the case of the vacuum and the velocity-type governors, the accuracy of control increases with a decrease in speed; whereas, with the mechanically operated centrifugal type, the accuracy of control increases as the speed increases. Fig. 11 affords a basis of comparison, being reproduced from the paper on Refinements in Truck Design[8], by H. D. Church, in which a paragraph explains the efforts directed at that time toward obtaining the minimum variation in speed between full load and no load, this being considered necessary for satisfactory operation.

[8] See S.A.E. TRANSACTIONS, vol. 11, part 2, p. 324.

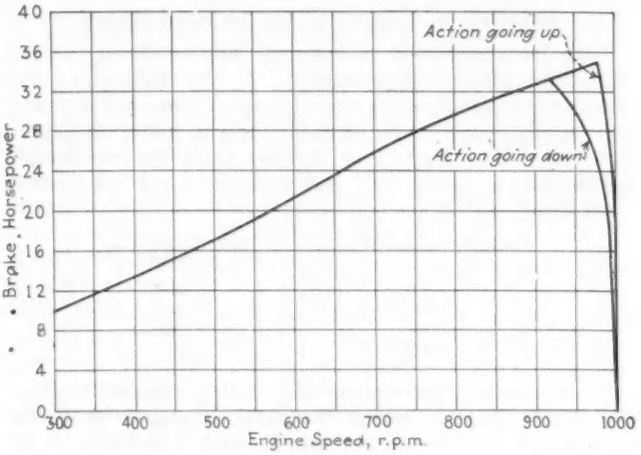


FIG. 11—REPRODUCTION OF HORSEPOWER AND GOVERNOR-CONTROL CURVE BY H. D. CHURCH IN 1916

Mechanical Constructions

The general construction of the velocity-type governor is shown in the left view of Fig. 6, together with the arrangement of the spring and cam. Its operating principle is based essentially on the use of an offset throttle-valve, usually of rectangular shape, which serves to produce the motive power and also controls the mixture volume which is contained within a flange, or adapter, and located between the manifold and the carbureter. The offset plate develops an operating torque on its shaft, due to the pressure difference above and below the plate, as shown by the curve in Fig. 12, indicating the general characteristics of this effort, or torque, in respect to angular displacement of the plate and relative speed. The torque is balanced by a spring in the housing that acts through the medium of the cam, which rectifies the resistance of the spring and

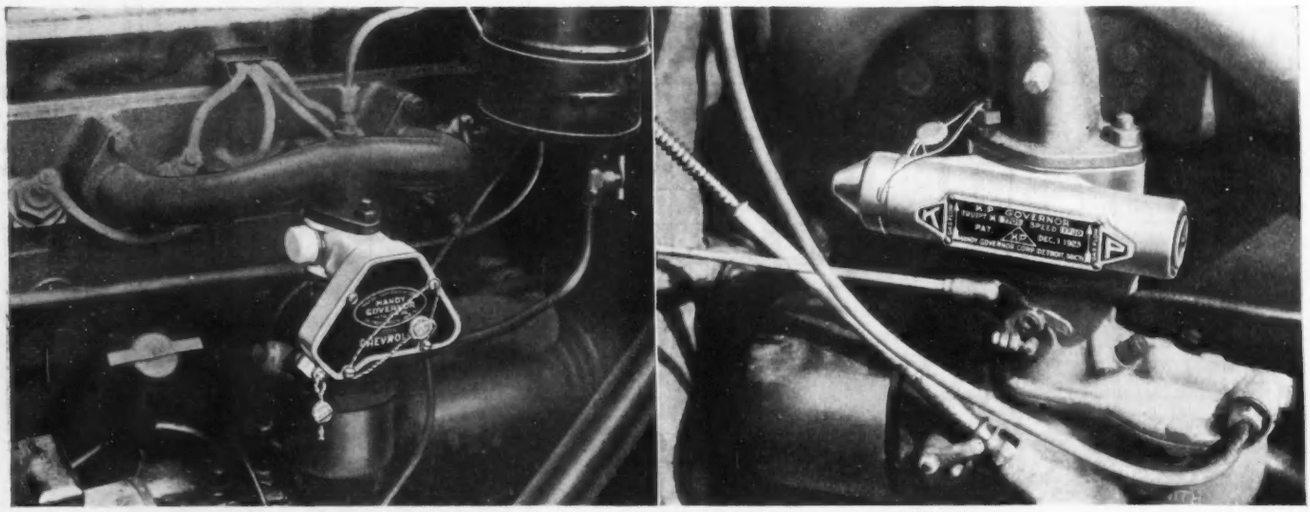


FIG. 10—TYPICAL INSTALLATIONS OF ENGINE-SPEED GOVERNORS

The Velocity-Type "Handy" Governor, at the Left, Is Installed between the Carbureter and the Inlet Manifold. An Installation of the Vacuum-Type K-P Governor Is Shown at the Right

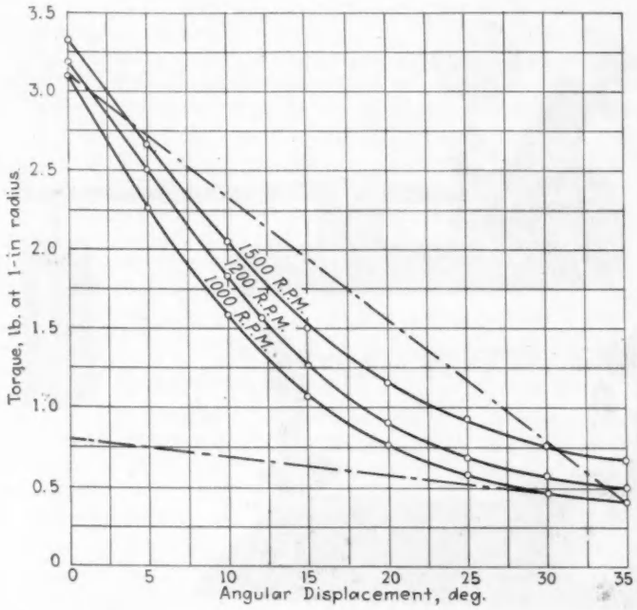


FIG. 12—CHARACTERISTIC THROTTLE-TORQUE DIAGRAM FROM A "HANDY" VELOCITY-TYPE GOVERNOR

produces a reaction equal to the torque curve of the plate. The operating pressures are substantial, and the difference in such pressures is of sufficient magnitude, with a small speed-difference, to create a movement of the throttle-plate, which responds to the changes in load on the engine.

Attached to the offset throttle-plate is a small stabilizing piston, operating in a cylinder attached to the flange of the governor. Its purpose is to facilitate the movement of the throttle-plate toward a closed position and also to correct for the disturbance of the operating pressures on the throttle-plate when the carbureter throttle below the governor throttle is closed, the effect of which is to open the governor valve. The vacuum piston is purposely made ineffective after the throttle-plate is one-half closed, this having a practical advantage in that the governor valve cannot assume a fully-closed position until the governor speed is reached, so that, during the normal operations of the carbureter throttle in accelerating or in changing gears, or under any condition in which the accelerator is let up to close the carbureter throttle, the governor valve is always partly open to eliminate any hesitation when re-accelerating, which is likely to occur when the governor closes and then has to reopen. The contour of the cam is substantially the same for all engines, because this shape was derived from a definite mathematical equation that was established by careful calculation and tests on a large number of different engines. However, changes are made in the position of this contour in reference to the fulcrum of the cam itself and its contact with the roller arm, which is attached to the throttle-plate shaft, to advance or retard the action of the governor.

Governor Calibrations

Standard specifications are used in the preliminary tests when calibrating this governor, and necessary modifications are made in the standards to obtain the best operation. The spring calibration can be changed easily, as indicated in Fig. 13, this being effected by the use of an adjusting nut attached to the spring so that the number of active coils of the spring can be changed when desirable. This facilitates original calibration, enables commercial variations in springs to be corrected and has the further advantage that it can be changed in service to provide for a different calibration, or speed, when required. For example, if a governor is calibrated to the factory specifications at 2600 r.p.m., using 17 coils, and is installed as standard equipment, and if, after the truck goes into service, it becomes necessary to reset the governor to a much lower speed, it may be necessary to change the spring calibration to obtain results that are equally effective; but this is accomplished easily by removing the adjusting screw and changing the spring block as shown in Fig. 13. Generally, the required flexibility of the spring, as represented by the number of active coils, increases in accordance with the speed of the engine, although one spring-setting will provide effective regulation of this type of governor within a range of 600 to 1000 r.p.m.

The installation of the governor be-

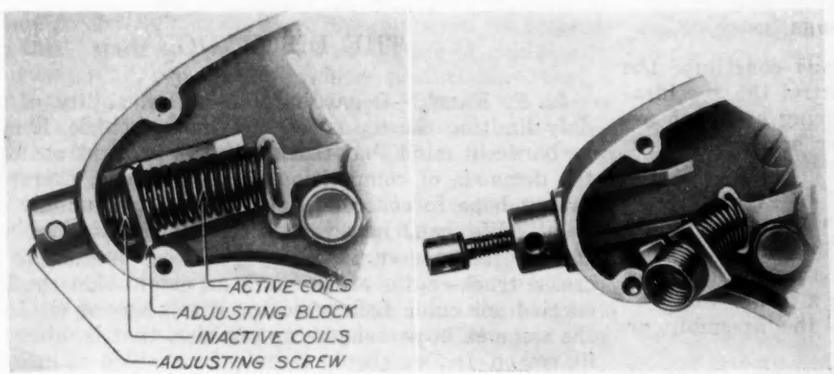


FIG. 13—PROVISION FOR CALIBRATING THE "HANDY" GOVERNOR
The Spring-Adjusting Device Is Shown in the Left View and the Method of Changing the Control Setting Is Illustrated at the Right

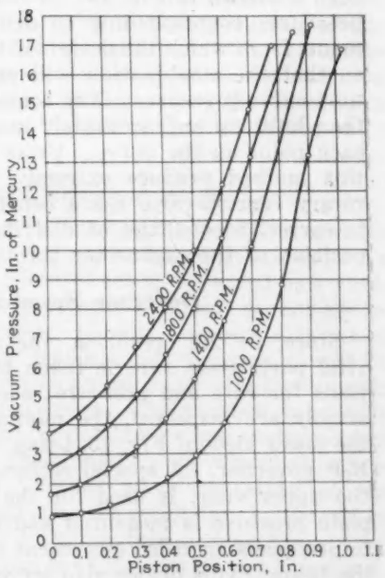


FIG. 14—VACUUM CURVES FROM A SIX-CYLINDER ENGINE OF 207-CU. IN. PISTON-DISPLACEMENT CORRESPONDING TO PISTON MOVEMENT AND VALVE POSITION ON THE K-P GOVERNOR

tween the carbureter and the manifold usually is arranged so that the governor throttle-valve is at right angles to the carbureter throttle-valve; in every possible instance the governor valve is set parallel to the center-line of the engine, because this has a favorable effect on the distribution of the mixture. The mechanical construction is such that the governor cannot be tampered with easily, or rendered inoperative, unless the seals are broken.

Vacuum-Governor Operation

The operation of the K-P vacuum-type governor, shown in section in the right view in Fig. 6, is based on the relation of manifold vacuum to torque, or horsepower and speed. The operating energy is derived solely from the engine suction-pressure and, as this is a definite and measurable quantity, the calibration is a simple matter of calculation notable for the accuracy and consistency of its results. It consists of a single body, comprising a cylinder and valve chamber. The throttle valve is of the rotary type, with venturi-shaped passages, and this provides for full volumetric capacity of the engine. The valve is operated by the piston through the gear-teeth, and the movement of the piston that is actuated by the suction is opposed by the multiple-spring unit so that its combined value balances the piston pressure.

A typical vacuum curve, obtained by dynamometer test, is shown in Fig. 14. A computation of the piston pressures corresponding to definite valve positions is made, from which the design of the springs is calculated so that the combination will exactly balance the vacuum-curve pressures. The complete spring-assembly is then built up and accurately measured for pressure at each point on the curve. Units built in production by this method produce extremly uniform results. The rotary venturi-valve has a beneficial effect, as it tends to correct inequalities of distribution arising from the position of the carbureter throttle below it.

Governor Speed-Settings

Since, in the operation, the springs constitute the vital part, great care is taken to control the specifications for rate and pressure; each spring and each assembly are inspected, the micrometer scales shown in the lower view of Fig. 15, being used for inspecting the K-P governor. A special calibrating fixture, shown in the upper view, is used for the Handy governor; the plate pressure is measured and the spring is adjusted to produce a specified movement with a given weight on the beam. This device also serves as a means for general inspection, and inaccuracies in the assembly or in the spring are readily detected.

While it is usual to set or adjust governors for speed after installation on the vehicle, this is not practicable at the factory in many instances, as when fleet owners who operate on a National scale desire to send adjusted and sealed governors into a certain territory. Therefore, governors of both the Handy and the K-P types are set and adjusted for speed before shipment, and are installed on engines without further change.

In conclusion, the opposition to governing formerly made by drivers and operators has almost entirely disappeared because of the better appreciation of the value of governors and because the performance of the governor equipment now available modifies the operation of the vehicle to a less extent than did the earlier devices. The 1915 statistics of commercial cars having governor equipment[4] reveals an increase in the number of governors used at present and a complete reversal as to the type used.

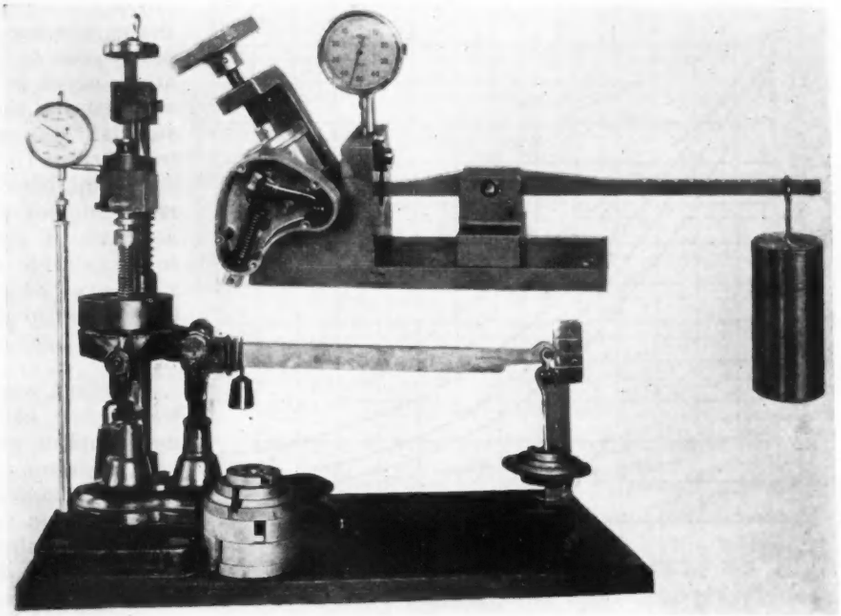


FIG. 15—DEVICES FOR TESTING AND INSPECTING GOVERNORS

(Upper View)—Special Speed-Setting and Inspection Fixture Used for Testing the "Handy" Velocity Governor

(Lower View)—Micrometer Spring-Weighing Fixture Used for Calibrating and Checking the Spring Assembly in the K-P Type of Governor

THE DISCUSSION

L. P. KALB[5]:—Regarding the undesirability of unduly limiting the top speed of a motor-vehicle, it must be borne in mind that truck speed is brought about by the demands of competition. The engineers, therefore, cannot hope to control truck speeds at an unduly low point. We can, however, control engine speed and thereby increase engine life. If it were possible to increase truck-engine size to such an extent that the load carried per cubic inch of piston displacement would be the same as in passenger-car practice, that is, about 22 lb. per cu. in., we should thereby be enabled to incorporate in truck engines the same degree of simplicity that we now have in passenger-car engines and would also be able to build them for the same price per pound. It is the extreme requirements made on truck engines that

[4] See S.A.E. TRANSACTIONS, vol. 11, part 1, p. 340.

[5] M.S.A.E.—Assistant chief engineer, Continental Motors Corp., Detroit.

forces us to incorporate costly features which we should prefer to ignore.

According to my observation, with the higher speeds at which six-cylinder truck-engines operate, the vacuum or velocity type of governor has more advantages than it formerly had. In the case of an engine which has a maximum torque at 1000 to 1200 r.p.m. and is operated at 2000 r.p.m., a slight reduction of the torque at the higher speeds will not impair the maximum ability of the vehicle. In the case of slower-speed operation, with maximum torque at approximately 900 r.p.m. and a governed speed of approximately 1050 r.p.m., close regulation is required to prevent the governor from reducing the maximum torque of the engine.

Limitations of Benefit from Governors

A. W. SCARRATT[6]:—Certain limitations exist regarding the benefit that can be gained by the use of governors. When an engine is governor controlled and the vehicle is operating at speed on a highway, it is distinctly limited as to its maneuverability. The vehicle may be running at a speed that is satisfactory so far as the powerplant is concerned, but a situation may arise that requires maximum performance of the powerplant to secure safety. A governor limits engine performance under such conditions.

We all think of governors with regard to the protection they should afford a powerplant. Governors are not speed-limiting devices for the engine under coasting conditions. The greatest damage that is likely to occur to an engine may happen under coasting conditions of long duration. In many sections of the Country it is possible to coast for several miles, and usually the transmission is set at one of the lower gear-ratios. If the driver is accustomed to a speed of say 40 m.p.h., and that speed is attained on a down grade, the engine probably is operating at a speed 50 per cent faster than when connected in direct drive; hence, a governor does not limit the possibilities of maximum engine-speed for such conditions.

Regarding truck-engine design, a successful engine must be viewed from two distinctly different angles. It must have a certain piston displacement and a certain amount of power and torque available at a desired speed of operation. But that does not determine entirely the strength the parts must have to resist the excessively high stresses induced by unreasonable coasting speeds.

Regarding the use of governors on chassis shipped to foreign countries, speeds are distinctly limited in some countries, and are very low compared with speeds in this Country. To take full advantage of engine output and still provide the vehicle performance that a purchaser expects, the builder is forced to deliver chassis equipped with maximum gear-ratios so that the engine can be speeded up and thus deliver the maximum power.

Any type of governor places certain restrictions on engine output. Some are rather disadvantageous in that respect. On account of the frequent lack of close speed-regulation, it is often doubtful how to govern the vehicle so that it will operate within a certain maximum speed-limit on the highway, which is mandatory in some States, or whether the governor should be set to limit the engine speed. In tests made with a fully loaded chassis with the engine governed so that it will perform at a definite speed on a level highway, we find that if the load is removed the chassis will over-run the limiting speed by as much as 15 per cent in some instances.

H. P. MCDONALD[7]:—We received recently an order from the Public Service Commission to remove all governors from our vehicles because of the hazardous conditions they create.

A. A. BULL:—Answering Mr. Scarratt and Mr. McDonald, we must consider that there is some limiting speed of a vehicle. If we assume a vehicle not equipped with a governor but moving along the highway at approximately its maximum speed and the occasion arises for it to pass another vehicle running at about equal speed, this seems to be a condition no different from that when operating a vehicle equipped with a governor that is set at some lower speed. Inability of one vehicle to pass another is relatively no different except that in one case the speed may be 50 and in the other case may be only 40 m.p.h.

Referring to the order to remove governors from motorcoaches, this hinges largely on the speed at which the coaches are controlled. If the governor control is at a speed set to satisfy operation conditions rather than some arbitrary low speed-limit, the risk is no greater, for the reasons just stated. But it is true that, if the governed speed is set considerably below the average operating speeds of vehicles in the territory, the maneuverability is disturbed. However, the conclusion remains that this subject is a matter of relativity. Sensing the limitations of speed as exercised by the governor in the one case and the inability in the other case by the vehicle itself, assuming that it is operating at or near its top speed, the conditions are no different.

There may be some hills on which a governor cannot provide suitable control, but I think a governor effects as much control as would be attained with the carbureter throttle. There obviously is some restraint on the speed, if, in coasting in low gear, the throttle is closed; and the governor functions in much the same way, automatically.

Shall We Govern Engine or Road Speed?

A. J. SCAIFE[8]:—Are we not trying to make a road-speed governor out of an engine-speed governor? An engine-speed governor should not be regarded as a road-speed governor. The governors available do not necessarily limit engine speed. Usually a governor is set at the maximum speed at which a given engine should be run, and no more power or ability is provided by setting the governor above that speed. The greatest value of a governor is that, when motor-trucks and motorcoaches are operating in the lower gear-ratios where ability is required on different grades when operating in the lower transmission-speeds, the operator is prevented from over-running the engine into a zone that is beyond the economical limits of its operation. When running in low gear, a situation may develop in which not all of the ability of the engine is required.

It is very difficult to judge the vehicle speed at say 20 or 22 m.p.h. by using the carbureter throttle entirely when going over long grades. If a driver has been accustomed to running at say 40 to 50 m.p.h. on the level, he finds it hard to judge the speed correctly

[6] M.S.A.E.—Chief engineer, motor-truck and coaches, International Harvester Co., Chicago.

[7] A.S.A.E.—Superintendent of equipment, Missouri Pacific Transportation Co., St. Louis.

[8] M.S.A.E.—Consulting field engineer, White Motor Co., Cleveland.

when using the lower gear-ratios. In such cases, the governor takes the responsibility from the driver and holds him to the speed at which the engine should be operated.

C. F. MAGOFFIN[9]:—A governor is merely a safety device and we use it only to protect the engine; so we set it to control engine speed at say 2200 r.p.m. or whatever speed has been calculated as a safe operating speed for the particular engine. I think a governor should not be used to govern road speeds, but only to prevent racing the engine.

Not a Substitute for Driver Supervision

F. K. GLYNN[10]:—A fleet operator is responsible for the supervision and management of his drivers; a governor is not a substitute for supervision. Governors should be set to operate at a speed just above the point of maximum torque of the engine. Gear-ratios should be selected initially to provide appropriate speeds for the operation of the particular type of vehicle. I believe that drivers should be supervised to maintain proper vehicle-speeds and that these speeds will usually be less than the governed speed. If this plan is followed, the objection to governors, that drivers cannot pass another vehicle, is removed. Indiscriminate cutting in and out, however, will be somewhat difficult on a governed vehicle.

In the foregoing, I am not attempting to say that we have reached the ultimate of perfection and that all drivers in properly supervised fleets will govern their speed to the limit set forth in handbooks and specifications, but I do maintain that this is a matter of supervision and that the governor should be regarded as the operator's protection in the lower gear-ratios where the driver has practically no knowledge of the number of revolutions per minute of his engine.

GEORGE P. ANDERSON[11]:—Several years ago we adopted governors on Dodge Brothers trucks both as extra and as standard equipment, but solely for engine protection. I believe that this is the light in which they should be considered.

F. C. MCMANUS[12]:—The sooner we get away from the idea that a governor is an accessory the better it will be for both the truck user and the manufacturer. If a governor is regarded as a standard part of an engine and not as an accessory, the driver will not expect to ignore its proper utility in the operation of the vehicle.

Experience with Governors

CHAIRMAN J. F. WINCHESTER[13]:—Based on our wide experience with the use of a governor, I offer the following comments. Mr. Glynn's statement that a governor is not a substitute for adequate fleet-supervision may be correct, but I have found that the supervisor of any large fleet of vehicles must have capable assistants, and a governor is one of the most reliable and economical assistants that can be employed to reduce upkeep costs. To a large degree, the amount of saving that will be made depends upon the vehicle design; the more regulated and carefully balanced it is, the less need for such a piece of mechanism.

On the other hand, in virtually every case, we place vehicles that range in cost from $3,000 to $15,000 in the hands of men who have had little experience in mechanical matters and, no matter how carefully we train the men, they will always speed when the opportunity presents itself unless prevented by some automatic device. This is not always the fault of the operator; he, in turn, is being pushed for results by a route supervisor or traffic man. I naturally feel that our own operation is carefully supervised. We have worked on the organization for a long period. Many of our personnel have been connected with us for 10 or 12 years, but we still find that this condition arises. The governor certainly has proved to me to be a capable assistant.

Thus far in this meeting the discussion of governors has centered on the benefits they afford the engine, but the engine constitutes only a comparatively small part of the chassis. In my opinion, all the other parts also should be protected. In many designs, if an engine is not protected from too high operating-speed, burnt-out bearings, crankcase trouble and similar results occur that are disastrous to economical operation; but we also should consider the effects on the transmission, universal-joints, rear axle and frame, and the tire mileage and the upkeep of all parts affected. The governor certainly contributes toward the economical maintenance of these parts. It also contributes, where solid tires are used, to the economical maintenance of the highway, and is an assurance that the driver will keep within the State laws. It is the duty of the supervisor who has to do with the specifications of the new vehicle to see that the proper gear-ratios are used for the territory in which the vehicle is to be operated; but this is no guarantee that the unit will not be abused after it goes into service.

I feel that the use of a governor has in many cases been the result of afterthought, and that we find it being installed today because the factory engineer or the factory service manager feels that it serves a useful purpose to both the operator and the organization that is guaranteeing the vehicle. Operators, having seen the difficulties that arise through the non-use of the governor, have felt the need of employing an assistant of this sort. The result is that governors have been increasingly specified, and the engineer must recognize that the operator who buys the equipment must be considered.

One recent instance was the refusal of a certain trade manufacturer to consider installing a governor on a certain high-speed engine. This resulted in the loss of a sale, and it is significant to note that the same manufacturer is today installing governors on the majority of his equipment as standard equipment. I have been convinced for a long time that a governor is a necessity, but the situation today is somewhat different, as so many vehicles are operating on pneumatic instead of solid tires. High speeds are the natural result that comes from the use of pneumatic tires. We should not overlook the effects on the highways that come from the use of solid-tired trucks which are heavily loaded and frequently run at high speed when ungoverned, but in the case of the pneumatic-tired truck or motorcoach, the necessity for some type of governor still remains. This is particularly true when the operator has to shift

[9] Commercial-car engineer, Reo Motor Car Co., Lansing, Mich.

[10] M.S.A.E.—Engineer, operation and maintenance of automotive equipment, American Telephone & Telegraph Co., New York City.

[11] M.S.A.E.—Director of sales engineering, Chrysler Corp., Detroit.

[12] Jun. S.A.E.—General engineering department, International Motor Co., New York City.

[13] M.S.A.E.—Superintendent of motor-vehicles, Standard Oil Co. of New Jersey, Newark.

to first, second or third speed. At these points in normal operation, the engine speed may be excessive and is sometimes disastrous. Certain motorcoach manufacturers of note take the precaution to place in front of the driver on an etched plate the safe road-speeds at which an engine can be operated in the various gears. This certainly is a decided improvement and should be a help. The use of this table also should be very valuable to the drivers in hilly country who use the engine as a brake. In some cases they attempt to drift down long straight hills, and engine speeds are developed that are beyond the safe limits and sometimes very disastrous.

Governors Needed on Solid-Tired Vehicles

MR. SCARRATT:—For trucks equipped with solid tires, I believe governors always should be used; but within the last several years the use of solid tires has almost been abandoned, even on heavy-duty trucks. All trucks are essentially fast trucks at present. We believe in governor equipment because it has very definite advantages, but using a governor-controlled high-speed chassis on a crowded highway involves a distinct risk. I know of instances in which, because of traffic congestion, a slower-going vehicle ahead forced the vehicle behind it to travel at a speed of 5 m.p.h. below its governed speed for a long time. There was plenty of power in the vehicle behind, but the driver did not get a chance to use it because his vehicle was nearly up to its governed speed and the time required to pass the vehicle ahead was too great, considering the congestion in traffic.

MR. GLYNN:—I believe that a governor is a valuable aid to the supervisor of a fleet, but I cannot agree that the governor should be set at the maximum speed for rough going; if that were done, it might result in setting the governed speed at 10 or 15 m.p.h., which would be absurd when the vehicle travels on the paved highway.

MR. SCAIFE:—There will always be a vehicle ahead that the vehicle behind cannot pass, and I believe that this point is being stressed too much. A test was made recently in Cleveland by the police department over a distance of about 5½ miles with two cars. The car that observed all the traffic regulations arrived at the end of the test route only 5 min. behind the car that disregarded traffic lights and other restrictions.

MR. GLYNN:—I recently followed a wild driver from 195 Broadway to Columbus Circle in New York City. I observed every traffic regulation and the driver who disregarded traffic regulations gained only two blocks in that distance by so doing.

Governors Lessen Restrictive Legislation

CHAIRMAN WINCHESTER:—Many of the restrictive legislative acts that have been enacted up to the present have been brought about by the abuse of State laws. The need for them would have been eliminated to a large extent if a speed-controlling device had been in universal use.

In a country territory in which we operate about 50 salesmen's cars of the moderate-priced type, we installed a governor on each to limit the speed to 45 m.p.h. We have since noted a very considerable decrease in the upkeep cost, as compared with the previous operation without governors. The salesmen do at least as much work, and we believe that there will be a decided tendency to accomplish more work because of the added time they will be on the road.

C. A. WINSLOW[14]:—If governors are satisfactory for salesmen's cars, it seems that they should be satisfactory for any car; but anyone who has had the experience of driving a vehicle equipped with a governor, whether it be an automobile, a motorcoach or a motor-truck, has found that there are certain disadvantages of governor-equipped engines, such as when trying to pass a vehicle ahead in congested traffic-conditions. It may also be true that the vehicle having a governor-equipped engine might be the cause of accidents because the acceleration is limited at a critical moment when it may be more desirable to accelerate and pass than to decelerate by setting the brakes. In the case of a vehicle without a governor, the driver has the option in a tight place of either decelerating or accelerating to avoid an accident. In the case of a governor-equipped vehicle, the accelerating advantage no longer exists and there is no choice but to stop, which may not be the right thing to do under the circumstances.

Public Feeling Against Reckless Truck Operation

CHAIRMAN WINCHESTER:—In heavy traffic the additional speed one might have over the governed speed is of no service because it cannot be used; but in country districts where traffic is not heavy the driver of a high-speed car can pass the car with governed speed. This constitutes a solution of the problem of decreasing accidents and maintenance costs. It is the driver who tries to pass a car that is governed to a speed of say 45 m.p.h. who runs off the road and causes damage.

As a contribution to the subject of governors and regarding the feeling of citizens toward the use and reckless operation of high-speed trucks, I quote in effect from a correspondent of the *New York Times* of Dec. 21, 1929.

> Recently, a healthy strong man anxious to support his wife and children was killed while driving a motor-truck which was struck by another motor-truck that was turning a corner at high speed, being pinned against the steering-wheel; but the world goes on just the same, and so do the heavily laden trucks which pass through our congested streets. The philosophy of the truck drivers seems to be that they have the right of way; and they strike and crush passenger-cars, mangle pedestrians and run down weak children. Should not some intelligent laws limiting the speed of trucks to a minimum rate be passed, those who violate them to be adequately punished?

The *Times's* editorial comment on the foregoing is very pertinent.

> The plea from one of our correspondents that a curb be placed on reckless driving of trucks will receive much sympathy, except from truck drivers and their employers, who apparently fail to understand that a truck is not an ordinary automobile, not even an enlarged and heavier automobile. Rather is it often a veritable juggernaut which, because of its size, momentum and clumsiness, is a menace alike to other cars and to pedestrians. On country roadsides the trucks are a peril already recognized, as well as a serious obstruction to traffic. In the city, when carelessly driven, they needlessly endanger the lives of

(*Concluded on p.* 249)

[14] M.S.A.E.—Development engineer, Hercules Motors Corp., Canton, Ohio.

Automotive Research

Recent Progress in Automobile Design

THE YEAR 1929 marked the introduction of the front-drive passenger-car. Its performance and acceptance are being carefully watched to determine whether it is merely a fad or has its particular place in the transportation field. The six-cylinder engine trend has now reached trucks of the largest size, as have pneumatic tires. To give greater carrying capacity, a new motorcoach design has been introduced in which the body and controls have been moved forward, with the engine projecting partly into the body.

The Research Department has been fortunate again this year in obtaining Austin M. Wolf's[1] critical survey covering the advances made during 1929 in the various phases of automotive research and design. Mr. Wolf presents in a simple, direct style his observations and opinions based on a long experience in the automotive-engineering field.

This article, written for and appearing in the American Year Book, is used here through the courtesy of that publication.

Engines

Eight-cylinder engines continue to gain, while 12 and 16 cylinders are being experimented with for the highest priced field. A V-type using two banks of eights is the first to reach the production stage. With the increasing demand for power in motorcoaches, the eight-cylinder engine has been introduced into this service to keep down the individual-cylinder dimensions and stresses.

There are two schools of combustion-chamber design, the older being exemplified by the Ricardo head, in which turbulence is used to speed up flame propagation in the endeavor to suppress detonation, while the newer school claims that turbulence is merely a means to obtain a uniform mixture and increase the rate of heat transfer. Engineers of the latter school aim to control the temperature of the part of the charge which burns last, by means of a high surface-volume ratio over that portion of the combustion-chamber, and in so doing to control the acceleration in the rate of pressure rise. Substantiation of this theory is to be found in an engine incorporating this principle and having a compression ratio of 5.8:1, which tops the ratios of engines capable of utilizing ordinary fuel.

Some designers have felt that compression ratios have gone too far for smooth operation, and we find the use of slightly lower ratios. In one instance there is a recession from 5.7:1 back to 5.15:1. With a slight increase in bore, the new engine develops greater power than did the former.

Valves and Pistons

Cylinder bores and valve diameters are still being increased. Placing valves horizontally in a V-engine results in a substantially triangular combustion-chamber shape. An L-head chamber has a spherical portion over the piston besides the pocket over the valves. Both inlet and exhaust valves in several engines have a 30-deg. seat for greater effective-opening area. Valve-springs with closed damping coils are used in one instance, while concentric springs, coiled in opposite directions, are used in another. As a cooling aid, aluminum bronze is used as the material for the exhaust-valve guide in a heavy-duty engine.

To be able to translate laboratory results into the field would be ideal, but deterioration in service prevents it. A step toward this ideal is to be found in the decarbonizer on one car, in which a plunger is provided to inject a charge of chemicals into the inlet manifold while the engine is speeded up, the chemical charge being left to stand overnight to soften the carbon.

A new high-silicon aluminum piston-alloy has been introduced that has a lower coefficient of expansion, which makes close fitting possible without the need of expansion slots or separation of the skirt from the head. Tungsten carbide has made its machining commercially possible. An alloy-piston design with slots and head separation has a cast-in slot dividing the piston-pin boss. The outer boss is on a vertical channel-shape web uniting head and skirt, while the inner boss is on a horizontal web uniting the skirt sections adjacent to the boss relief.

A motorcoach alloy piston of the constant-clearance type has two invar rings cast in, one at the lower edge of the skirt and the other immediately above the piston-pin bosses. Another development involves the use of a flat invar strip projecting through opposite slots in the second ring-groove and holding the ring out at a constant clearance in the cylinder. The strip, being centrally anchored to the head, holds the piston in permanent axial alignment with the cylinder. The skirt is slightly oval and expansion due to temperature rise increases the effective bearing area along the thrust axis. Removing the oil-control ring from the skirt to above the piston-pin with alloy pistons improves lubrication, especially during the time required for warming up in cold weather.

Connecting-Rods, Bearings and Shafts

Aluminum-alloy connecting-rods are on the increase. Rigidity of the big end is assured in one instance by the use of a case-hardened steel cap.

A foundry accomplishment that results in extreme rigidity is the casting of a V-eight crankcase and cylinders in one unit. Replaceable steel-backed babbitt-lined main bearings are often line-reamed after installation, but progress in the fabrication, with limits as low as 0.00025 in. on some dimensions, allows their installation or replacement without any fitting. Camshaft bearings of this type are appearing. A copper-lead bearing compound is used by one motorcoach manufacturer. It has no lining or backing, the structure being uniform throughout the shell.

Experiments are being conducted with a new type of steel for camshafts and crankshafts that does not require heat-treatment. Shaft, cams and gear made separately and brazed together in a hydrogen atmosphere is a new development in welded camshafts.

[1] M.S.A.E.—Automotive consulting engineer, Newark, N. J.

Oil capacities have been increased in some instances. The space below a false bottom and between numerous transverse ribs provides settling chambers in one lower crankcase. To assure a supply of oil regardless of engine inclination or oil viscosity, an inverted cup is placed over the vertical cylindrical screen surrounding the pump intake of one engine. An instrument has been developed to give continuous viscosity indications of the oil in the crankcase.

Cooling

Thermostatically-operated vertical-vane radiator-shutters replace the radiator false front. They are of full length and conform to the characteristic curvature of the radiator. When operated, the vanes turn in from both sides. The increased power of present-day engines is reflected in their greater water capacity. In place of even water distribution from the pump, all the water in one engine goes to the rear of the block and then flows forward. One maker claims substantially increased fan-belt life through the adoption of two narrow belts in place of the single wide one formerly used. For more favorable fan position behind the radiator, the combined fan-and-pump unit has been raised. The pump upper contour is often above the top of the block.

Fuel System and Manifolding

The downdraft carbureter is a conspicuous development of the year. Improved distribution and a cooler manifold are made possible by its use. The manifold can be of larger diameter, increasing the volumetric efficiency. A drain is provided at the bottom of the manifold T to prevent overloading in case of excessive choking. Greater valve accessibility is afforded with the carbureter above the engine. Downdraft manifolding is also on the increase. One carbureter is provided with an extra high-speed jet which cuts in at 50 m.p.h. Different carbureter calibrations are now provided on cars going into low and high altitudes.

An automatic heat-control valve consists of a butterfly valve in the exhaust manifold, weighted at its lower end to hold it normally closed, at which time the exhaust is bypassed through a jacket on the intake. As the engine speed increases, the exhaust pressure opens the valve. The inlet manifolds on a motorcoach engine are water-jacketed, and the flow of water through them is controlled by a thermostat. This same engine draws air at atmospheric temperature from outside the hood or can be made to draw it from an exhaust stove.

Air-Cleaners and Engine Governors

An air-cleaner of the copper-ribbon type, oil-wetted, is also an effective flame arrester in case of backfire. Considerable spiralling of air through a cleaner upsets uniform distribution in the manifold. Great care must be exercised in the design of an air-cleaner to straighten out the air-flow before it enters the carbureter.

Camshaft-driven fuel-pumps are increasing, a new type involving a float and a pressure chamber, the latter reacting on the former when the carbureter needle seats, thus preventing further pumping.

Owing to operators running motorcoaches in the lower gears at excessive engine-speeds, governors are being used to safeguard against these destructive speeds rather than the engine speed in high gear. To prevent high speed in factory drive-aways, governors are being installed which are removed when the cars have reached their destination and returned to the factory for further use.

Several cars have increased gasoline-tank capacities. A vent in the center of the tank prevents spilling when turning corners. On one car the gasoline pipe-line is carried outside the frame channel to expose it to the cooling air. A gas generator for fuel oil has been developed for motorcoaches. A Roots-type supercharger is available on one car.

Clutches

Ventilating covers are provided in the clutch compartment. In one case a duct from the outside is brought near the release bearing, admitting air to relieve the vacuum created at the center of the revolving mechanism, thereby preventing lubricant being sucked into the clutch from the transmission. A new clutch design of the single-plate type utilizes a full circle of stamped-steel levers between the spring and pressure plate, assuring uniform pressure. A number of radially disposed laminated springs act as a cushion drive in the clutch hub.

Transmissions

Indirect-gear ratios have been slightly reduced to increase acceleration. The quest for quietness continues, with finer pitch and smaller diameters giving lower pitch-line velocities. Internal-gear reduction is increasing, and ease of shifting is more pronounced by shortening two out of every three teeth of the sliding-gear clutch, giving a combination tooth-and-dog effect.

The customary latch-out of four-speed transmissions is being eliminated by means of a spring-loaded plunger which requires additional side-pressure to overcome. A four-speed all-spur-gear type unit is used by one maker. A three-speed transmission has appeared with built-up herringbone gears for the constant-mesh and second-speed trains, the latter having different pitches on the adjacent members. Horizontally disposed shafts are to be found in motorcoach and front-drive transmission designs, to give increased road clearance. A new five-speed truck type has appeared, as has also a four-speed motorcoach transmission with second and third-speed trains in constant mesh.

Universal-Joints

Front drive requires universal-joints capable of deflection to an included angle of at least 40 deg. from a straight line. A special design is required to assure uniform angular-velocity. A compact double joint is used in one instance, with the adjacent aligned pins of the two joints secured to a central ring which always bisects the angle. Another design utilizes steel balls which roll in raceways ground in the joint yokes, the plane of the balls bisecting the joint angularity.

Rear Axles

A dead rear axle, reminiscent of chain-drive days, reappears with the advent of front drives. A double roller chain is being experimented with by a manufacturer of chain-driven trucks. A two-speed axle appears in the form of an internal-gear reduction unit ahead of the bevel pinion. A three-quarter-floating design replaces the full-floating axle on two cars.

Front Axles

Front drive again revamps previous axle design. A tubular center member in one instance is offset for-

ward to clear the differential housing, and the ends are swedged into forged yokes in which the king-pin centers are in line with the drive-shafts. The center portion of the I-beam axle-bed in another vehicle is offset forward to clear the worm housing.

Brakes

While one maker returns to a 50-50-per cent front and rear braking effort, another places the distribution at 60-40 per cent. A friction-type servo unit for installation at the rear of the transmission has been developed, as have also flexible-cable connections to replace brake-actuating rods and levers. Lead-tipped shoes as well as a lining having lead wire interwoven therein reduce scoring through a seemingly "lubricating" effect, dampen noise and aid in shedding water. The engine brakes through the front wheels on front drives. One design has the drums adjacent to the differential housing and acts through the universal-jointed shafts.

Wheels and Tires

Improved swedged spokes and chromium-plating characterize the increasingly popular wire wheel. Large chromium-plated hubs are popular with wood wheels. While one maker replaces roller with ball-bearings for the wheels, another moves oppositely. The heavier cars are going to small-diameter rims, with tires such as 18 x 7.00 in. Inroads are being made by the balloon tire in the truck field.

Suspension

The last adherent of the cantilever spring has dropped it. Spring-shackles of the rubber-bushed type are more popular. Springs heavily coated with graphite lubricant, wrapped in heavy canvas and provided with metal covers obviate any further need of interleaf lubrication. A new form of shock eliminator provides a shackle at the front of the left spring in place of the fixed mounting, its oscillation in both directions being restrained by helical springs under compression.

Two parallel quarter-elliptic front springs at each side, the lower one being adjustable fore and aft by a fine thread for caster adjustment, provide a constant caster angle during spring deflection. Tests show that, in striking an obstacle or when braking, the axle may rotate as a whole as much as 5 deg. and with a wide wandering of the instantaneous center of rotation, thereby entirely upsetting the steering geometry. With the advent of front braking and driving, this is a serious matter. Front radius-rods are another possibility.

Frames

Increased channel depths and widths, the latter particularly where offsets occur, are noticeable. An X member is used near the center of several frames to give rigidity. By placing a deep drop in the spring-seat of the rear axle of one front-drive car, no frame kick-up is required.

Control

Three-spoke steering-wheels and the starter button on the instrument board are noticeable trends. While wheelbases have been increased several inches, the turning circle of many cars has been decreased several feet. Decreased steering effort is obtained in the cam-and-lever gear by allowing rolling motion of the stud through its mounting in roller-bearings. Pedals mounted separately from the powerplant, a cable connection in place of a rod and the use of rubber in the gearshift-lever mounting aim to suppress noise transmission. A horizontal rod projecting through the instrument board, with a knob on the upturned offset, provides the gearshift for front-drive cars.

Equipment

The metric spark-plug is used more. A cover extends over the heads of some engines to protect the spark-plugs. The double-breaker type of ignition is more popular on six-cylinder engines, one breaker serving the three front and the other the three rear cylinders. A new ignition lock is built into the coil and attached to the rear of the instrument board.

Starters of the mechanical-shift type have lower reduction-ratios. One make with higher cranking speed uses an 18-deg. advance beyond the normal driving-range for starting because of better results in cold weather. The horn located in the center of the lamp tie-rod is an innovation. Some cars are now provided for radio installation.

Headlights continue large. Head and tail-light wires are entirely concealed. Parking lights are placed at the top of the front body-pillars on one car, but revival of this antiquity seems to have no place in a vehicle symbolizing speed. A combination tail-and-stop light utilizes a 21-cp. lamp, the intensity of which is reduced by resistance in the circuit. Application of the foot-brake short-circuits the resistance and the full intensity is used for "stop."

Hydraulic shock-absorbers of the two-way type show increased usage. A thermostatic valve consisting of a conical disc controlling the oil-flow aperature provides consistent operation with varying climatic changes.

Sheet Metal and Body

Radiator shells on several cars have depressions in the sides and sometimes on the top, finished in the body color, the raised portion being chromium-plated. Radiator caps are so flat as to be almost invisible in some cases. Shutters make possible the V-shaped false front of a front-drive car. Longer and flatter hoods are the vogue. A series of triangular wing-like groups following the upper fender line, each consisting of several curved louvers of increasing length, imparts to the vehicle the effect of motion, even while standing still. Vertical louvers are provided near the radiator in one case for the discharge of dust sucked in through the radiator. The hood hinge is continued across the cowl to the windshield in several plated, decorative designs.

Fenders hang lower over the wheels and have considerable sweep in the front-drive designs. In them are to be found exceptionally long, tapering hoods. Running-boards are provided with curved edges to be continuous with the fender edge. Full-length running-board kick-pads are used. Rear gas-tank covers extend to the fenders to fully cover the rear spring-horns.

New Body-Tretament

Over-all body-heights are generally lower, with extreme lowness in the front-drive cars, which offer body designers fresh possibilities, from new methods of terminating the front end to the lack of restrictions, including the kick-up in one car, at the rear end. Doors and body side-panels are brought flush with the running-board splashers in several cars. Increased seat width is obtained by flaring the bodies out slightly

below the belt molding. Body panels are coated with a noise deadener, such as emulsified asphaltum, to eliminate drumming and provide heat insulation. Many joints between the wood frame-members and the metal braces have graphite-paper inserts to prevent squeaks. The use of steel in bodies is increasing. There is a growing tendency for manufacturers to build their larger model in two wheelbases to give greater body variety. Several closed as well as open models provide contrasting-color panel effects, in which the hood color is carried below a bead dropping down and rearwardly over the cowl and lingering along the bottom of the body.

Windshields are tilted slightly, about 7 deg., to avoid glare, following open-car history. Plated windshield and window frames are used. Opaqued glass is still used for sun vizors, while some car makers employ individual, adjustable flaps hinged to the roof above the front seats. Drop-type rear windows aid ventilation. Because of the small depth over the wheelhousing in a low design, the rear-quarter window is hinged in front and swings outwardly. Improved cowl ventilation is popular, and is secured by providing either dual ventilators at the top or one ventilator at the top and one on each side of the cowl.

There is an increasing use of the all-metal side roof-shell, replacing fabric. Roof treatment usually shows the side panels tapering in depth toward the front. The English sliding roof has been introdued. Replaceable chromium-plated body moldings, sliding over a steel strip spot-welded to the body panels, are an innovation, as are plated window-moldings. The use of a single molding, about 3 in. wide, is displacing the widely spaced molding with the belt between. One maker has eliminated the plated cowl-band, which has no rightful place where vertical lines should be suppressed.

Many bodies are mounted on the frame on rubber shims for increased quietness. One maker uses rubber molded directly to a ⅛-in. steel floor-plate, the rubber extending beyond the plate to form a seal and also on the under side where the plate rests on the sill.

Refinements of the Interior

A folding arm-rest divides the rear seat into two sections when required. Two layers of springs are used in some seats, the lower layer being of fairly heavy stock to guard against major road unevenness, while the light upper layer is form-fitting and takes up minor deflections. A variety of seat-adjusting means are provided, such as a self-locking screw, a spring-loaded pin dropping into holes in a runway, or the use of several holes in the cushion frame into which fit lugs projecting from the seat pan. The latter is used for an adjustable rear seat.

Comfort is to be found in arm rests of molded sponge rubber, which have built-in ash receivers. An elbow rest is attached to the left front door of one make. An extension cord permits operation of the rear-curtain by the driver. Lockers are built into some instrument boards. Thick sponge-rubber padding under the carpet gives a luxurious touch. For the fastidious, floss-stuffed pillows are provided, covered with a material duplicating the upholstery and set off by edgings of contrasting colors. Foot cushions replace the conventional foot-rail. Sometimes a robe of fleece is furnished.

A key design is often worked out and will be found on all interior fittings, instruments, hardware, lamps, radiator emblem and cap, hub caps and bumper assembly. One car carries into the cowl a V effect at the rear of the hood, and it is used again at the front of the roof, on the sun vizor and down the rear of the body. Stainless steel is being used for hood hinges, running-board moldings, door handles, hub caps, fuel-tank caps and crank covers. Its future is promising.

Body service-stations have been established through the Country, and manufacturers probably will benefit as much by becoming acquainted with their product in the field as the public will gain by this long-felt need.

Application of Engine Governors to Transportation Equipment

(*Concluded from p.* 245)

children and adults particularly in turning corners and when they take on speed. So long as they go slowly they can be tolerated because necessary, but when they go fast their very power makes them dangerous. More control, either voluntary or enforced, would be welcomed by helpless citizens.

In my opinion, a great deal remains to be done by commercial-vehicle operators to overcome the general sentiment that exists against the use of heavy-duty trucks which is clearly set forth in the foregoing quotations. The last sentence of the editorial carries great weight. If all operators of commercial vehicles will exercise more voluntary control by employing governors for speed regulation, they will make a valuable contribution toward relieving adverse sentiment.

MR. KALB:—The principal offenders as far as overspeeding of vehicles is concerned are not the responsible corporations, but the smaller companies and individual operators who are faced with bitter competition. This is why they speed up their engines, use engines that are too small for their vehicles and do all the things which shorten vehicle and engine life and thereby give the equipment a bad name.

Since all the truck engineers here present seem to agree that speed limitation is necessary, it behooves them to take a strong stand with their salesmen and, through them, with their customers. A check-up of the standard gear-ratios of most responsible truck companies shows that all are fairly reasonable as to the relationship between vehicle and engine speed. It is the optional gear-ratios which cause most of the trouble. There seems to be a strong tendency for truck salesmen to demand these increased optional gear-ratios. This should be resisted by the truck engineer.

Standardization Progress

Division Reports Approved

Discussion of and Action Taken on Reports to Standards Committee at Annual Meeting

ALL of the reports submitted by Divisions of the Standards Committee at the Annual Meeting, except that on Metric Spark-Plugs, were approved in the form submitted, as published in Section 2 of the January issue of the S.A.E. JOURNAL, or in slightly amended form as indicated in discussion on the various subjects which is printed herewith. The page reference following the proposed status of each report refers to the page in Section 2 of the January issue on which the report appears.

The revised and new reports adopted as S.A.E. Specifications will be published in the 1930 edition of the S.A.E. HANDBOOK that is now being printed.

Agricultural Power-Equipment Division

TRANSMISSION ROLLER CHAINS, SPROCKETS AND CUTTERS

(*Proposed American Standard, p.* 3)

O. B. ZIMMERMAN:—I regard this report one of the finest pieces of work we have accomplished in standardization. It is so fully explained in the printed report that I do not believe it is necessary to call particular attention to anything in it. This report is a good example which could be followed for many other standards we are working on, in that it includes many practical data concerning applications of these standard chains.

Aircraft-Engine Division

AIRCRAFT-STARTER MOUNTING

(*Proposed S.A.E. Standard, p.* 13)

L. M. WOOLSON:—Mr. Senart, of the Army Air Corps, has pointed out one discrepancy in the report which I should like him to discuss.

B. F. SENART:—The only objection the Army Air Corps has to this recommendation is the depth of the tooth on the engine dog. The present S.A.E. Standard is 9/32 in., while in this recommendation it is 7/32 in. The Air Corps would recommend that this be changed to 9/32 in. so that there will be a deeper slot for engagement and to make it possible to interchange the present starter with the new one.

MR. WOOLSON:—Mr. Majneri, I believe you were responsible for formulating this report; have you any objection to changing it?

LUDWIG A. MAJNERI:—No; I think the dimension could be changed.

Aircraft Division

AIRPLANE WHEEL RIMS

(*Proposed Revision of S.A.E. Recommended Practice, p.* 14)

E. P. WARNER:—It has been found desirable to make a minor change in the present standard dimensions of two sizes of rim to bring them into conformity with the Tire and Rim Association's Standard.

MAJOR C. W. HOWARD:—The Army Air Corps has no objection to these changes but we should like to know why they are made.

B. J. LEMON:—The ledge width was changed because, for certain tire beads, the ledge was not quite wide enough to take the entire bead. For the larger tires the rims were largely experimental when the specifications were drafted, and I have an amendment to this report to change two other dimensions which are affected in the same way as the ledge width of the rim. We have found that, on the 10 and 12-in. rims for airplane tires, the mounting of the stiff beads is difficult with the well depths that were specified. The Tire and Rim Association has already increased these well depths by 1/16 in., changing the 31/32-in. depths on the 10-in. rim to 1 1/32 in. and the 1 3/32-in. depths on the 12-in. rim to 1 5/32 in.

MR. WARNER:—The policy of the Aircraft Division has been uniformly to follow the recommendations of the tire-manufacturing members when recommendations relate to tires and rims and do not affect the relation between the wheel and the rest of the airplane. I will accordingly accept Mr. Lemon's amendment.

AIRPLANE TIRE VALVES

(*Proposed Revision of S.A.E. Recommended Practice*)

This report was presented as an additional one to those printed in Section 2 of the January issue of THE JOURNAL, as it had been acted on by the Aircraft Division following publication of the printed reports.

MR. WARNER:—The Airplane Tire-Valve Standard on p. 21 of the August, 1929, Supplement to the S.A.E. HANDBOOK should be modified in one respect in accordance with the Tire and Rim Association's specifications. Dimension *A*, the length of the valve from the entry to the tube to the bend, is increased for valve No. 62 from 2⅜ to 2¾ in. Dimension *B*, for valve No. 62, is reduced from 2 9/16 to 2⅛ in., and the angle by which the bend is less than 90 deg. is increased from 30 to 39 deg. The reason for this is that it was found that the valve made in accordance with the original specification has caused certain interferences in application to certain wire wheels.

Ball and Roller-Bearings Division

ANNULAR BALL-BEARINGS, SINGLE-ROW TYPE

(*Proposed American Standard and Proposed Revision of S.A.E. Standard, p.* 14)

ANNULAR BALL AND ROLLER-BEARINGS, WIDE TYPE

(*Proposed American Recommended Practice, p.* 14)

Electrical Equipment Division

METRIC SPARK-PLUGS

(*Proposed Revision of S.A.E. Recommended Practice, p.* 20)

D. M. PIERSON:—The spark-plug in this report will be slightly different from that used in aircraft engines, and it is the desire of the Division to standardize the plug as outlined in the report, the major change being that the threaded length of the skirt shall be 7/16 in. rather than as given on p. 29 of the August Supplement to the S.A.E. HANDBOOK, which specifies ½ in. for the entire skirt length. All other dimensions remain the same.

O. C. ROHDE:—Since the meeting at which this report was approved, I have been experimenting to find out how nearly we could approach the 7/16-in. length in production and have found that the longest thread length we can use is 27/64 in., or 1/64 in. less than the recommendation, due to the method of staking the wire points.

MR. PIERSON:—We can amend the report subject to confirmation by the Subdivision on Metric Spark-Plugs and thus remove the objection to the detail which might stand in the way of its passage by the Standards Committee. I move that, in case the proposed

change in the report is not confirmed, the present S.A.E. Recommended Practice for Metric Spark-Plugs referred to in the August Supplement to the HANDBOOK be cancelled pending adoption by the Society of a revised report.

[Although the Standards Committee passed the report with the amended revision and approved the cancellation of the present S.A.E. Recommended Practice on p. 29 of the August Supplement to the S.A.E. HANDBOOK in any event, the Council referred the report back to the Division for further consideration. Refer to the account of action taken by the Council and the Society at its Business Session on the Reports of the Divisions.]

SPARK-PLUG TESTS

(*Proposed Cancellation of S.A.E. Recommended Practice, p.* 21)

STARTING-SWITCH LOCATION

(*Proposed Cancellation of S.A.E. Recommended Practice, p.* 21)

TEMPERATURE TEST OF INSULATING MATERIALS

(*Proposed Cancellation of S.A.E. Standard, p.* 21)

STARTING-MOTOR CABLE

(*Proposed Cancellation of S.A.E. Standard, p.* 21)

RUBBER-BUSHING HOLES

(*Proposed Cancellation of S.A.E. Recommended Practice, p.* 21)

Iron and Steel Division

HEAT-TREATMENT DEFINITIONS

(*Proposed Revision of S.A.E. General Information, p.* 21)

Lighting Division

LABORATORY TESTS OF OPTICAL CHARACTERISTICS OF ELECTRIC HEAD-LAMPS FOR MOTOR-VEHICLES

(*Proposed S.A.E. Standard Based on a Revision of Present S.A.E. Recommended Practice, p.* 22)

C. A. MICHEL:—The Lighting Division held a meeting this morning at which some minor revisions in the report as printed were made. The first one is in the paragraph on Incandescent Lamps, which is somewhat limiting if interpreted literally, therefore it was decided to add the following sentence to this paragraph:

Where special incandescent lamps are specified, such lamps shall be submitted with the device and the same or similar lamps used in the test and operated at their rated mean spherical candlepowers.

In the paragraph on Set-Up for Testing, the second sentence was revised to read:

The head-lamps shall be tested in pairs or as used and shall be aimed in accordance with the applicant's instructions.

The fourth sentence in this paragraph was deleted.

The next revision referred to is in the Lower Beam Specification. It was voted this morning to omit the values given in the specification under Maximum Permissible Beam Candlepower, Any Point.

LABORATORY TESTS OF OPTICAL CHARACTERISTICS OF TAIL-LAMPS FOR MOTOR-VEHICLES

(*Proposed S.A.E. Standard Replacing S.A.E. Recommended Practice, p.* 24)

TAIL-LAMP CONSTRUCTION

(*Proposed S.A.E. Recommended Practice, p.* 24)

TAIL AND SIGNAL-LAMP MOUNTINGS

(*Proposed Change from S.A.E. Recommended Practice to S.A.E. Standard, p.* 25)

LICENSE-PLATE BRACKET-SLOTS

(*Proposed Revision of S.A.E. Standard, p.* 25)

LICENSE-PLATE HOLES

(*Proposed S.A.E. Standard, p.* 25)

Motorboat Division

MOTORBOAT ELECTRIC INCANDESCENT LAMPS

(*Proposed S.A.E. Recommended Practice, p.* 25)

W. M. JOHNSON:—Some modifications that are mostly in the nature of editorial changes and corrections of the tabulated data in this report have been made since it was printed. The first is to change the drawings of the lamps and to include the sizes not shown that are in use. The letters referring to the dimensions of the bulbs should be the same in all illustrations. The only other changes were current ratings on some of the lamps and the type of bulb used for the 10-watt lamp. A footnote has been added referring to the differentiation between design amperes and maximum amperes. This footnote now appears on p. 134 of the S.A.E. HANDBOOK for incandescent lamps for headlights and other uses on passenger-cars and reads:

Improvement in lamp design and manufacture from time to time makes possible changes in ampere ratings. The figures given are therefore maximum and are for use in calculating wire sizes and battery capacities. For test purposes the exact amperage should be obtained from the lamp manufacturer.

This provision is necessary because the current ratings on lamps change periodically as improvements in efficiency are made and therefore the maximum currents shown need be used only for calculating purposes. The headings in the table under captions *A*, *B* and *C* should be omitted.

Non-Ferrous Metals Division

CHROMIUM-PLATING

(*Proposed S.A.E. General Information, p.* 26)

DIE MATERIALS AND RARE METALS

(*Proposed S.A.E. General Information, p.* 27)

Passenger-Car Division

BODY-TYPE NOMENCLATURE

(*Proposed Revision of S.A.E. Standard*)

G. L. MCCAIN:—Some modifications that a minority of the Division has more or less agreed upon are proposed in the report as printed. I believe that with the following modifications we can approve the report for final adoption.

It has been proposed that the name Touring Car, which has been previously taken out of the standard, be changed to Seven-Passenger Phaeton. The elimination of Touring Car, which really is a misnomer today, is a good change.

It is proposed to substitute the description of Sport Coupé as follows:

A Coupé specially adapted for sport use with fixed top, frequently of fabric material, with landau joints. The rear deck is usually provided with a rumble seat accommodating additional passengers. Various refinements or extra equipment are frequently provided, such as ultra-modish finish, wire wheels and golf-club locker in the rear deck.

The only change for the Cabriolet is to specify it as Cabriolet or Convertible Coupé.

It is next proposed that the general description of Sedan should read:

An enclosed four-door-type body with permanent back panels and top. A full-width cross seat in front and rear. Passenger capacity from five to seven according to wheelbase or body design. Auxiliary folding seats in rear for accommodation of extra passengers in the larger types. May or may not be provided with windows in the rear quarter. Variations from the standard sedan type may be variously designated as Two-Window Sedan, Three-Window Sedan, and Sedan, Club Sedan, Close-Coupled Sedan, Landau Sedan and so on, but there is not sufficient uniformity in these variations to justify specific standardization.

With the substitution of the description for Sedan that I have read, the two drawings in the report can be combined or both can be shown to illustrate the use of landau joints in the two-window sedan. This change will combine the special types of sedan rather than to have two or three illustrations that show only minor differences.

The revised definition for Landau is a clearer description than the one printed and means the same thing. It reads:

A closed-type body with provision for opening or folding the rear quarter by the use of landau joints. This usually precludes the use of quarter windows.

With regard to the Imperial Sedan,

Mr. Mercer has suggested that the name Berline, which has passed down from the carriage days and perhaps should be included, would make the title of this type read, Berline or Imperial Sedan.

The definition for Town Car will read:

Same as Imperial Sedan with or without quarter windows and without a fixed roof over the front compartment. A folding or removable weather-proof fabric top over the front compartment is a usual but not restrictive feature of this type.

For Convertible Sedan it is proposed to add the word "any" so that the description will read:

Similar to any Sedan type with provisions for converting to an Open-Type Car.

followed by the rest of the description as in the report.

I move that the recommendation as corrected be adopted subject to approval by the Subdivision on Body-Type Nomenclature.

Footman Loops

(*Proposed Cancellation of S.A.E. Recommended Practice, p. 30*)

George Mercer:—Footman loops are used on passenger-car bodies to fasten down tops and wherever straps are required, but the sizes are made to such liberal tolerances that a standard need not be maintained.

Passenger-Car Doors

(*Proposed Cancellation of S.A.E. Recommended Practice, p. 30*)

Top-Bow Supports

(*Proposed Revision of S.A.E. Recommended Practice, p. 30*)

Wiring for Beads

(*Proposed Cancellation of S.A.E. Recommended Practice, p. 30*)

Wood Screws

(*Proposed Cancellation of S.A.E. Recommended Practice, p. 30*)

Body-Parts Nomenclature

(*Proposed Revision of S.A.E. Standard, Additional Report*)

A few changes in the wording of the present nomenclature, commencing on p. 546 of the 1929 issue of the S.A.E. Handbook, that had been approved by the Passenger-Car Division without dissenting votes since the reports of Divisions to the Standards Committee were printed, were reported. By oversight, no copy of the proposed revision was available at the Standards Committee Meeting and it was voted to refer the matter back to the Division. When this subject was reported to the Council of the Society at its meeting subsequent to the Standards Committee Meeting, the action of the Standards Committee was reversed and the report approved following a full explanation of the circumstances.

The items as revised are as follows, the item numbers corresponding to those in the present S.A.E. Standard:

30—Rear Quarter Pillar, Rear
34—Wheelhouse Frame, Rear
40—Wheelhouse Frame, Front
41—Rear Quarter Pillar, Front
44—Rear-Door Rear Pillar
49—Rear-Door Front Pillar
50—Front-Door Rear Pillar
56—Front-Door Front Pillar
57—Front Body Pillar

Production Division

Milling-Cutters

(*Proposed American Standard, p. 30*)

Woodruff Key-Slot Cutters and Gages

(*Proposed Revision and Extension of S.A.E. Standard, p. 41*)

Plug and Ring Gages

(*Proposed Revision of S.A.E. Recommended Practice, p. 45*)

Taps—Cut and Ground Threads

(*Proposed American Standard and Revision of S.A.E. Standard*)

Screw-Threads Division

Wrench-Head Bolts and Nuts and Wrench Openings

(*Proposed Revision of American Standard and S.A.E. Standard, p. 50*)

Slotted-Head Screws

(*Proposed American Standard and S.A.E. Standard, p. 50*)

E. H. Ehrman:—This report of Subcommittee 3 of the Sectional Committee on Bolts, Nuts and Rivets, that is sponsored by the Society and the American Society of Mechanical Engineers under the procedure of the American Standards Association, includes slotted-head machine-screws, cap-screws and wood-screws for all usual sizes and the various types of head. There are a few minor typographical changes, principally in headings and arrangement of wording, that should be made to clarify the meaning of the tables. This report was approved by the Screw-Threads Division last month with the exception of Table 2 for Round-Head Machine-Screws that has involved the question of smaller heads on some of the sizes. However, at another meeting of the Division this morning, the report was approved in whole to avoid further delay in making the complete report available as the general standard for National industrial use.

To meet a demand in the automotive industry for round-head machine-screws having smaller head dimensions, a supplemental series of this type of screw is to be considered by the Division and a specification prepared to meet the wants of the automotive industry and industries at large throughout the Country. The report is also submitted for approval and adoption as an S.A.E. Standard, with the exception at this time of that part of the report regarding the screw lengths.

Track Bolts and Nuts

(*Proposed American Standard, Additional Report*)

Mr. Ehrman:—Since the reports for this meeting were printed, the Division has received and acted upon a proposed American Standard for Track Bolts and Nuts. After acting favorably on it at the meeting of the Division this morning, it is now submitted to the Standards Committee for approval. This type of bolts and nuts is not used in any way in the automotive industry, and the Society is interested in approving the report only as a sponsor organization under the procedure of the American Standards Association. Copies of the report are available to those who may be interested in it.

Tire and Rim Division

Tires and Rims for Passenger-Cars

(*Proposed Revision of S.A.E. Standard, p. 56*)

Mr. Lemon:—There is no table of tires and rims for passenger-cars in the S.A.E. Handbook at present because there has been such a radical revision in tire specifications that it was not printed in the Supplement to the Handbook last August. The table now submitted has been set up somewhat differently from previous tables. Fifteen sizes of tire are proposed where previously there were 19, thus eliminating four sizes for use as original equipment. The tire sizes are designated by the rim diameter instead of the over-all tire diameter, under the new method of the Tire and Rim Association. The proposed table includes the nominal rim widths as well as the actual rim widths for the flat-face rims, as it has been confusing to refer to a 4-in. rim that measures only 2.69 in. between flanges. Two drop-center rims that are used as original equipment are included. The word "balloon" has been removed from the heading of the table, since all tires now used as original equipment on passenger-cars are of the balloon type.

Balloon Tires and Rims for Commercial Vehicles

(*Proposed Revision of S.A.E. Standard, p. 56*)

Mr. Lemon:—At the last meeting of the Tire and Rim Division, a 5.00—20 tire was voted into the table, but the industry has not yet agreed upon what this tire shall measure, nor have the rims or the loads and inflations for the

5.00 tire been worked out. This tire section has been omitted from the table but will be given consideration in the future with regard to making it a part of the S.A.E. Standard.

High-Pressure Tires and Rims for Commercial Vehicles

(*Proposed Revision of S.A.E. Standard, p. 56*)

Passenger-Car Tire-Load and Inflation-Pressure Table

(*Proposed Revision of S.A.E. Recommended Practice, p. 58*)

Mr. Lemon:—This table is the same as that printed in the August Supplement to the S.A.E. Handbook except that a revision has been made for the 6.00 section tire by decreasing each inflation pressure by 50 lb. In plotting the deflection curves for the balloon tires, this size was found to be a little out of line.

Truck and Motorcoach Balloon Tire-Load and Inflation-Pressure Table

(*Proposed Revision of S.A.E. Recommended Practice, p. 58*)

The only change in this table is the inclusion of the 5.50, the 6.00 and the 6.50 tire sections.

Dual Spacings for Truck and Motorcoach Balloon and High-Pressure Tires

(*Proposed Revision of S.A.E. Recommended Practice, p. 57*)

Mr. Lemon:—The method of designating the tire sections has been changed somewhat in printing the report. In the table under the heading Permits Oversizing, the 5.00 tire size for the 7¼-in. spacing should be omitted; and the 5.00, 6.00, 7.00, 8.00 and 9.00 balloon-tire sizes for the 7¾, 9, 10, 11½ and 12¾-in. center-to-center spacings respectively should be changed to 5, 6, 7, 8 and 9-in. high-pressure tires. Likewise, under the heading Does Not Permit Oversizing, the 5.00, 6.00 and 10.00 balloon-tire sizes for the 7¼, 7¾ and 12¾-in. center-to-center spacings respectively should be changed to 5, 6 and 10-in. high-pressure tires.

Reports Approved by Council

All of the reports acted on at the Standards Committee meeting were approved by the Council as passed by the Standards Committee with the exception of the following:

Metric Spark-Plugs

The Council referred the dimensional part of this report back to the Electrical Equipment Division for further consideration, as it was not deemed advisable to make the suggested revision in the report as presented without such an important detail being given more consideration by the Division. That portion of the report to the Standards Committee cancelling the present S.A.E. Recommended Practice was approved by the Council.

Body-Parts Nomenclature

In reviewing the circumstances surrounding the submission of this report to the Standards Committee, the Council felt that the proposed revisions could properly be approved for inclusion in the 1930 edition of the S.A.E. Handbook and accordingly reversed the action taken by the Standards Committee. The proposed revisions are given under this subject in the reports of Divisions to the Standards Committee.

Society Business Session

All of the reports of Divisions to the Standards Committee, as approved or amended by the Council immediately following the Standards Committee meeting, were approved at the general Business Session of the Society held Monday evening, Jan. 20, and ordered to publication in the 1930 edition of the S.A.E. Handbook.

The following Standard Committee members, Society members and guests were present at the Standards Committee meeting:

Standards Committee Members

C. C. Bohner
A. Boor
E. J. Bryant
R. S. Burnett
C. F. Clarkson
D. S. Cole
E. E. Dearth
H. C. Doane
E. H. Ehrman
R. N. Falge
W. T. Fishleigh
H. W. Graham
W. S. Haggott
Maj. C. W. Howard
H. S. Jandus
W. M. Johnson
C. M. Larson
B. J. Lemon
L. E. Lighton
G. L. McCain
L. A. Majneri
A. L. Martinek
C. A. Michel
W. H. Oldacre
W. J. Outcalt
L. O. Parker
O. A. Parker
H. N. Parsons
D. M. Pierson
A. J. Scaife
B. M. Smarr
C. W. Spicer
F. W. Stein
W. R. Strickland
R. R. Teetor
L. Thoms
A. J. Underwood
E. P. Warner
J. M. Watson
F. A. Whitten
F. G. Whittington
T. H. Wickenden
L. M. Woolson
O. B. Zimmerman

Members and Guests

V. G. Apple
N. C. Banks
B. D. Barrow
J. S. Black
Edison Botts
H. B. Burr
L. K. Cohn
J. M. Davies
F. L. Faurote
W. H. Fenley
F. C. Frank
Joseph Geschelin
H. E. Goeppel
C. P. Grimes
G. R. Gwynne
E. J. Hergenroether
S. D. Heron
W. M. Horton
C. V. Johnson
C. B. LePage
H. L. Lowry
G. J. Mercer
G. E. Nicholson
A. E. Norton
M. Phelps
E. W. Reed
O. C. Rohde
B. F. Senart
J. A. Siegel
R. D. Smith
J. A. Thompson
J. C. Tuttle
E. S. Twining
R. E. Willis

Production Engineering

A Quality Department

Specialists Organized To Serve as Clearing House Between Various Pierce-Arrow Divisions

AT A recent meeting of the Buffalo Section, C. R. Nicodemus, assistant to the vice-president in charge of production of the Pierce-Arrow Motor Car Co., told the members something about the quality department of his company. Following is the substance of his remarks:

The quality department was created by B. H. Warner, vice-president in charge of engineering and manufacturing, and he personally conducts its activities directly from his office. The object of the department is to assure that the highest possible degree of quality is built into the Pierce-Arrow cars at all times. To accomplish this, it was decided that Mr. Warner's contact with the various production divisions should be constantly maintained through an assistant and a corps of specially selected contact men. Five different groups compose the quality department, each group representing one of the five general units of production, as follows:

(1) Mechanical details of chassis (engine, transmission and differential)
(2) Body (framing and paneling)
(3) Paint
(4) Plated or stainless-steel parts
(5) Upholstery

A highly proficient specialty man, working directly under the assistant to the vice-president, is assigned to each of these general production-units. These men and their departments have nothing whatever to do with production or inspection; their function is strictly non-productive.

Heading Off Trouble

The quality department has proved an indispensable division of the company. It is effectually heading off trouble at the very source, and thus preventing it from coming up later when the car is in the hands of the owner.

Authority is given to this department to call a meeting of the production foremen and regular inspectors of any production division at any time. Any question concerning doubtful standard of workmanship or materials can be threshed out at this meeting and definitely settled on the spot. Such meetings are held in the vice-president's office, sometimes as often as two or three times a week. Only one subject is discussed at a meeting. For example, if the general-inspection department's reports show that a certain number of bodies are written up for paint defects after mounting, the quality department immediately assigns its paint specialist to check up the paint department. His job is to go to the very bottom of the trouble in the paint department, find out the actual causes that underlie the trouble and see that they are entirely remedied.

All complaints, suggestions and criticisms sent in by distributors or dealers, as well as all general-inspection reports originating in the various divisions of the production department, are checked carefully by this department. All complaints, regardless of source or kind, are tabulated, and the totals give a very true and clear picture of the production quality of every unit or part of the car and serve to focus attention at any point in production where attention is most needed. The corrections initiated by this department are all made through the inspection or the engineering department. If a change in design may be required, it is first thoroughly investigated by the quality department and then checked by the engineering or inspection department before being put into effect.

Securing Interest and Harmony

This department has found that tne smoothest way to improve quality is to work with the foremen and operators and see that every man is inspired with a personal interest in his work. If a workman on a certain assembly or operation should, by accident, spoil a piece of material, he will then be interested enough to see that it is replaced by a good piece before the foreman or inspector is obliged to take up the matter with him.

Of course it is the earnest desire of the management that every operator should be so proficient as to carry on as far as possible without the aid of an inspector. This should be more nearly possible in our plant than in the rustle and bustle of the large-production plant, and the highest quality of individual workmanship is necessary to us.

One of the things that contributes most to the quality manufacture of an automobile is the harmony and co-operation between the various divisions, especially the production and inspection departments. If these departments are at loggerheads, it is not only difficult to get out schedule production; it is almost impossible to give the product the high quality demanded by the management and by the motorwise car-owner of today.

I do not mean to intimate that we have more than the ordinary amount of trouble between the different departments, but there are times when difficulties do arise in any plant. When such times have come, the quality department has justified its existence one hundred times over in its ability to straighten matters out quickly.

Replying to a question at the same meeting in regard to control of the engineering department by the production department, A. F. Carlson, assistant body engineeer of the Pierce-Arrow company, said that the two departments should work closely in harmony. The Pierce-Arrow production department can suggest to the engineering department any changes that it finds necessary or desirable. In no case was it recalled that the production department asked for a change that was not immediately investigated and, if found practical, approved wholeheartedly by the engineering department. Thus each department is ready and willing to help every other department in every possible way.

Casting Cylinder-Blocks

ANY man whose business it is to design, cast or machine engine cylinders will find much of interest in the paper on Casting Cylinders in Green Sand, on p. 177 of this number of THE JOURNAL. This is written by D. J. Campbell and is based on extensive experience in making cylinder castings in both dry and green sand.

Illustrations of various methods of molding and casting and of foundry and core-room layouts will be found to be very instructive and suggestive to others, as well as to foundry men.

Transportation Engineering

Vehicle Tire Manufacture

Processing the Fabric, the Making of Tire Treads, and Tire Performance Outlined

THE compounding of the rubber and the processing of the fabric are the first manufacturing processes necessary in the construction of motor-vehicle tires, said J. W. Stavely, of the Firestone Tire & Rubber Co., in a paper he presented at a meeting of the Northwest Section. Continuing, he stated that the rubber is placed on a mill equipped with horizontal rolls and, as it is worked, heat is generated and the rubber becomes soft and plastic. Various pigments such as sulphur, zinc oxide, accelerators and the like are added to the rubber while it is in the plastic state. A definite amount of these materials is used and the whole is mixed for a given time on a given type of mill having a given ratio and surface speed of the mill rolls. The mixture of these materials, when completed, is tested for dispersion and cure before being approved for production.

Calendering of Tire Fabric Outlined

The cord fabric, used in the tire casing, is passed through a calender which consists of three or four horizontal rolls mounted one above the other. These rolls may operate at odd or even speeds. Some manufacturers first impregnate the fabric with rubber before passing it through the calender because, in this manner, additional rubber insulation is obtained. The calendered fabric is processed with a high degree of precision, considering the fact that rubber is a plastic material. It is possible to calender fabric with rubber on a commercial basis within a tolerance of 0.0015 in. The calendered fabric is cut on the bias to the proper width necessary to extend from bead to bead of the tire. The angle at which the fabric is cut is usually between 35 and 45 deg. This angle largely determines the contour of the tire, a shorter angle giving a higher profile and a longer angle a lower profile. The general practice is to have the cords in the cured tire at an angle of 45 to 60 deg. at the crown of the carcass.

The amount of expansion during cure varies from 5 to 10 per cent and is necessary to assure proper alignment of the individual cords that make up the carcass of the tire. This expansion is obtained by building the tire slightly smaller than the mold in which it is to be cured. An air bag is placed in the green tire and kept inflated during the vulcanization or cure. This internal pressure brings the outside of the tire in contact with the mold and provides the necessary pressure for the proper vulcanization into a compact unit.

Tire Treads and Beading Discussed

The tire tread of today represents a marked improvement over that of 15 years ago. In those days most treads were white, because at that time zinc oxide was the generally accepted material for making the best-wearing tread. That was partly because this pigment could be obtained in a finer form than most materials. Later it was found that certain types of gas black are much finer than zinc oxide and make better-wearing treads; so, today, we find that practically all tire treads are black.

The tread of a tire is necessary, first, to give a long-wearing surface and, second, to give a non-skid surface. The resistance of a tire tread to wear not only necessitates high-quality materials, properly fabricated, but also involves the design of both the tire and the tread. Thus a large area of contact of the tire tread with the road affords a greater tractive surface and distributes the wear over a larger area. However, there are limitations as to tread contour, as it is essential to avoid localizing the flexing action of the carcass.

The function of the cushion and breaker in a tire is to distribute the road-shock impact and shearing stress and thus overcome the tendency for localized action at the top of the tire carcass. The double-cord-breaker construction, which consists of two narrow plies of cord fabric over the crown of the tire, is used extensively in heavy-duty tires. This construction not only gives better distribution of road shock in the large tires, but also gives a better anchorage of the tread to the carcass.

The plies of rubber-coated fabric that constitute the tire carcass are cut on the bias and assembled in the tire so that the cords in each ply run in the opposite direction to the adjacent plies. This gives greater strength and results in a more uniform distribution of load on the individual cords in the tire. Some manufacturers use an extra-heavy gage gum between the plies of motor-truck and motorcoach tires. This provides additional insulation between the plies, thus overcoming any possibility of ply contact which might result in tire failure.

The beads of truck tires are made up of several plies of wire strands. Some beads are known as single beads, and consist of one group of wires; others are of twin-bead construction consisting of two individual groups of wires in each bead. The twin-bead construction affords greater bead-stability and permits a better anchorage of plies around the bead wire because a greater number of plies can be anchored around the twin beads and yet keep the bead as low as possible in the tire.

Conditions Influencing Tire Performance

Even though a truck be equipped with the right size of tire inflated to the recommended pressure, this is no assurance of satisfactory tire performance. The mechanical condition of the truck is very important. Wabbly wheels, dragging brakes, loose bearings, loose steering-gear or tie-rod connections and the like all contribute to premature wear.

The alignment of both front and rear ends is important. It is not an infrequent occurrence to find a negative camber in the rear wheels due to bent axles. This condition causes the inside of the inside dual-tire to wear prematurely and in an uneven manner. A rear end out of line with the frame or front end will also cause premature wear on rear tires.

The front-end alignment is a much discussed question, but probably all will agree that maximum tire-wear will be obtained when the load is evenly distributed across the entire tire-tread and with the wheels moving in a straightforward direction when loaded.

A camber of 1 deg. with the truck loaded, should not cause premature tire wear. There is, in fact, a marked tendency in this direction in modern car-design. With a given camber setting the Feragen three-way testing-board is a good means of determining the amount of toe-in that will give minimum scuffing. Incorrect toe-in is one of the greatest offenders as regards tire

(*Concluded on p.* 257)

Administrative Committees for 1930

Announced at Council Organization Meeting Jan. 20—The 1929 Council Approves Organizing Two Sections

AT SESSIONS of the 1929 Council held in Detroit on Jan. 20 the following were present: President Strickland, President-Elect Warner, Councilors Parker, Berry, Fishleigh, White, Templin and Whittington, Chairman Apple of the 1929 Sections Committee, and F. C. Horner and C. B. Whittelsey, Jr., members-elect of the 1930 Council. In addition to routine business, the report of the Standards Committee, for submission on adoption at the Business Session of the 1930 Annual Meeting of the Society, was approved.

Organization Meeting of Council

The organization session of the 1930 Council was also held in Detroit on Jan. 20, with the following in attendance: President Warner, Past - President Strickland, Vice-Presidents Davis, Horner, McCain, Scaife and Younger; Councilors Fishleigh, Glynn, Parker and Teetor, and Treasurer Whittelsey.

President Warner announced the personnel of the 1930 Administrative Committees as follows:

Constitution Committee

J. C. Chase, *Chairman*

B. B. Bachman — W. T. Fishleigh

Finance Committee

D. Beecroft, *Chairman*

W. L. Batt — J. W. White
Joseph Bijur — C. B. Whittelsey

House Committee

R. S. Dresser, *Chairman*

A. L. Beall — S. L. Bradley
O. M. Brede — L. J. Heinrich

Publication Committee

John Younger, *Chairman*

F. O. Clements — W. L. LePage
M. C. Horine — J. F. Winchester

Membership Committee

F. K. Glynn, *Chairman*

A. M. Jones, *Vice-Chairman*

J. R. Cautley — E. F. Lowe — L. D. Seymour

Chairmen of Section Membership Committees

Buffalo	E. W. Kimball
Canadian	A. Bentley
Chicago	R. E. Wilkin
Cleveland	E. R. Jackson
Dayton	F. W. Sampson
Detroit	F. F. Kishline
Indiana	C. Merz
Metropolitan	William Harrigan
Milwaukee	L. Reinhard
New England	R. F. Lybeck
Northern California	V. W. Dennis
Northwest	S. Bushnell
Pennsylvania	G. S. Davis
Southern California	J. E. Van Sant
Washington	C. H. Warrington

Chairmen of Professional Activities Membership Subcommittees

Aircraft and Aircraft Engine	G. W. Lewis
Diesel Engine	A. L. Poole
Motor-Truck and Motorcoach	A. W. Herrington
Passenger-Car	J. R. Bartholomew
Passenger-Car Body	C. B. Parsons
Production	J. W. Brussel
Transportation and Maintenance	F. K. Glynn

Meetings Committee

J. A. C. Warner, *Chairman*

W. R. Griswold, *Vice-Chairman*

E. S. Land — Alfred Reeves — N. G. Shidle

Chairmen of Section Meetings Committees

Buffalo	A. F. Carlson
Canadian	F. N. Horton
Chicago	J. P. McArdle
Cleveland	A. K. Brumbaugh
Dayton	C. H. Kindl
Detroit	P. J. Kent
Indiana	L. Schwitzer
Metropolitan	A. M. Wolf
Milwaukee	P. W. Eells
New England	L. W. Martin
Northern California	E. Zeitfuchs
Northwest	E. B. Staley
Pennsylvania	J. P. Stewart
Southern California	F. C. Patton
Washington	C. S. Bruce

Chairmen of Professional Activities Meetings Subcommittees

Aircraft	C. B. Harper
Aircraft-Engine	Arthur Nutt
Diesel-Engine	L. M. Woolson
Motor-Truck and Motorcoach	E. M. Schultheis
Passenger-Car	W. C. Keys
Passenger-Car Body	A. E. Northup
Production	Joseph Geschelin
Transportation and Maintenance	Adrian Hughes, Jr.

Sections Committee

B. J. Lemon, *Chairman*

N. G. Shidle, *Vice-Chairman* (Pennsylvania)

Member-at-Large	D. P. Barnard
Member-at-Large	W. C. Keys
Buffalo	E. R. Boeck
Canadian	A. S. McArthur
Chicago	A. W. Scarratt
Cleveland	O. A. Parker
Dayton	V. G. Apple
Detroit	J. M. Crawford
Indiana	F. S. Duesenberg
Metropolitan	A. L. Beall
Milwaukee	F. M. Young
New England	Albert Lodge
Northern California	A. H. Lacey
Northwest	R. S. Taylor
Southern California	E. B. More
Washington	Thomas Neill

Standards and Research Committees

The names of the members who will serve this year as Chairman and Vice-Chairman of the Standards Committee and its Divisions were reported. Arthur Boor will be Chairman and G. L. McCain and C. A. Michel, Vice-Chairmen, of the Committee. The names of the Division Chairmen and Vice-Chairmen, as well as those named by the Council for service this year on the various Divisions of the Standards Committee, are listed elsewhere in this issue of THE JOURNAL; also the 1930 lists of members serving on various committees connected with the standards work and other matters, and as representatives of the Society in the activities of other organizations or in work jointly conducted by the Society with other organizations. Some of the men, however, have not yet accepted their appointment.

B. B. Bachman was named as Chairman of the Research Committee for 1930. The personnel of the Research Committee, as well as of the Subcommittees of that Committee, is listed on p. 259 in this issue of THE JOURNAL.

With regard to meetings of the Council during the year, it was felt that generally speaking these should be held monthly in 1930 except in the summer.

Professional Activities Committees

With the inauguration during this administrative Society year of recognized Professional Activities under revised Constitutional provisions, each Vice-President representative of his respective Professional Activity names, in conference with the Council, the Committee of the Activity, designating, in addition to a large number of engineers engaged actively in the special fields of work, a Vice-Chairman and Chairmen of Meetings and Membership Subcommittees. Each Vice-President becomes automatically the Chairman of the respective representative committee. The personnel for the 1930 Professional Activities Committees is given elsewhere in this issue of THE JOURNAL. These committees are: Aircraft Committee, Aircraft - Engine Committee, Diesel-Engine Committee, Motorcoach and Motor-Truck Committee, Passenger-Car Committee, Passenger-Car-Body Committee, Production Committee and Transportation and Maintenance Committee.

President Warner, Past - President Strickland and General Manager Clarkson were named as the members of the

1930 Executive Committee of the Council.

Proceedings at Jan. 9 Council Meeting

The session of the Council held in New York on Jan. 9 was attended by President Strickland, President-Elect Warner, Past-President Wall, Vice-Presidents Kliesrath and Sawyer, Councilors Fishleigh, White, Parker and Moyer, and Treasurer Whittelsey, of the 1929 Council; and by F. K. Glynn, Ralph Teetor, W. N. Davis, O. D. Treiber, C. M. Vought, A. J. Scaife, and C. B. Whittelsey, Jr., members-elect of the 1930 Council.

A discussion was had of Section budget matters, reference being made to the Sections Committee of points involved in the coordination of Section policies as to dinner charges, hall rent, payment of speakers' expense, and cost and distribution of printed announcements of Section meetings. The Sections Committee was also asked to consider the matter of recommended revisions of the Sections Guide.

At this Council meeting and subsequent sessions held later in the month in Detroit, 179 applications for individual membership and 28 transfers in grade of membership were approved. Six reinstatements were made and 8 applications reapproved.

The financial statement as of Nov. 30, 1929, was submitted and discussed. This statement showed a net balance of assets over liabilities of $237,708.91, this being $30,060.04 more than the corresponding figure on the same day of 1928. The gross income of the Society for the first two months of the fiscal year amounted to $70,409.35, the operating expense being $62,465.30. The income for the month of November was $37,258.98, and the operating expense during the same month last year was $34,069.82.

New Probationary Sections

The Council approved the petition for organizing an Oregon Section of the Society, with headquarters at Portland, the territory of this new Section having been included previously in that of the Northwest Section, with headquarters at Seattle.

Furthermore, the revival of the Minneapolis Section, which was discontinued some years ago, as the Twin-City Section, was approved.

In connection with Section membership in general, it was reported that during this Section administrative year 3933 Society members had paid Section dues, as compared with 3589 Section members who paid their dues during the 1928-1929 year.

W. H. McCoy was named as a representative of the Society on the Special Research Committee on Cutting of Metals, organized by the American Society of Mechanical Engineers some years ago.

Transportation Engineering

(*Concluded from p. 255*)

wear and one of the simplest conditions to correct.

A change from solid to pnuematic tires may result in premature tire-wear from misalignment, as many trucks with solid tire equipment have more camber than some of those equipped with pnuematic tires. If the condition is reflected in tire wear, then one's car dealer should be consulted, as he may be able to correct the condition. If necessary and desirable, camber can be changed by means of an axle press, but it is equally important to keep the same amount of camber and caster in both front wheels.

Best Practices for Welding the Different Metals

GRAY-IRON castings have little ductility and, therefore, must not be subjected to internal stresses that may be set up by expansion and contraction caused by the welding heat, said Orlie Trentham, of the Linde Air Products Co. in a paper he presented at a meeting of the S.A.E. Club of Denver, Colo. When gray cast-iron is to be welded, he continued, it is usual to preheat the casting, either locally or in its entirety, to weld while the metal is at a dull-red heat and to anneal by slow cooling after the weld is finished. Another reason that this is necessary is to avoid the possibility of chilling the weld metal and thereby transforming it into white cast-iron, which is extremely hard and unmachinable.

Preheating is usually accomplished by means of a kerosene torch or a temporary furnace built up with loose firebrick, fired with charcoal and covered with asbestos paper. In the case of small castings, preheating can be done with the blowpipe. Gray cast-iron parts of all kinds have been successfully welded for years by the observance of proper procedure. The average welder is familiar with the required technique. This process is especially applicable to the repair of broken machine-parts and is saving enormous sums of money annually. It obviates the expense of replacement parts and maintains the continuity of manufacture, which otherwise would be at a standstill pending the arrival of new parts from the foundry.

Cast-iron welding is also extensively employed for reclaiming defective castings at the foundry by filling in cold-shuts and blowholes. Such castings formerly had to be replaced and were good only for remelting. Gray cast-iron is welded with cast-iron welding rod. The use of a suitable flux is necessary because the oxide formed and the impurities in the metal tend to form a coating on the surface of the molten metal so thick that it interferes with welding. A properly prepared flux will react with these impurities, forming a fusible slag that can be removed easily.

Bronze-Welding Practice

Malleable-iron castings can be repaired successfully by bronze-welding, since the temperature required by this process is not sufficiently high to destroy the valuable properties of this material. Bronze-welding is accomplished through the use of bronze welding-rod and a suitable flux. This process is not true fusion-welding. The edges of the pieces to be joined are merely heated to a dull red, whereupon they can be "tinned" with bronze. The bronze is then filled in and built up to the desired thickness, and a very strong bond results; in fact, a properly designed bronze weld will develop the full strength of the parent metal. The usefulness of bronze-welding does not end here, however, as it also can be applied to gray cast-iron in many cases. When it can be so employed, it sometimes eliminates the necessity of preheating and annealing. For this reason bronze-welding is widely used throughout the industry for the repair of gray-iron parts as well as for malleable-iron parts.

Welding Non-Ferrous Metals Described

Practically all of the commercial non-ferrous metals can be successfully welded by the oxy-acetylene process. Most important among these are aluminum, brasses and bronzes, monel metal and copper. Each of these metals requires a special technique and a special welding-rod and flux. Aluminum, especially, in both sheet and cast form, is being extensively welded for many purposes. Airplane fuel-tanks, for instance, are practically all being constructed by this method and, in several instances, these have withstood the terrific impact of crashes without even springing leaks.

Papers Printed in This Issue

READERS interested in Transportation would do well to read the papers printed in this issue that bear on the subject. The discussion of E. D. Sirrine's paper on Engineering and Service relationships in the Truck Industry begins on p. 201.

A. A. Bull's paper on Governors for Automotive Engines, starts on p. 235, and F. C. Horner's paper, on the Application of Motor Transport to the Movement of Passengers, begins on p. 185.

S.A.E. Committees for 1930

THE personnel of the Professional Activities, Technical and Special Committees of the Society for 1930 is given on this and successive pages. Included in this list are the Research Committee and its Subcommittees and Cooperating Committees, the Standards Committee and its Divisions, the Society's Special Committees, and other organizations in which the Society is represented. Acceptances of their appointment have not yet been received from all of those named.

Personnel of the Administrative Committees for 1930 is given in the report of the Council organization meeting in this issue of THE JOURNAL on p. 256.

Professional Activities Committees

AIRCRAFT ACTIVITY COMMITTEE

Chance M. Vought, *Chairman*	Chance M. Vought Corp.
J. C. Hunsaker, *Vice-Chairman*	Goodyear Zeppelin Corp.
E. E. Aldrin	Standard Oil Co. of N. S.
Thurman H. Bane	The Aviation Corp.
H. M. Crane	General Motors Corp.
Brig. Gen. B. D. Foulois	U. S. Army Air Corps
Carl Fritsche	Detroit Aircraft Corp.
Lieut. Carl B. Harper	Bureau of Aeronautics, U. S. Navy
E. L. Land	U. S. Navy
Kenneth M. Lane	Department of Commerce
W. L. LePage	Kellett Aircraft Corp.
George W. Lewis	Nat'l Advisory Committee for Aeronautics
Major Leslie MacDill	U. S. Army Air Corps
C. J. McCarthy	Chance M. Vought Corp.
L. D. Seymour	National Air Transport
B. Russell Shaw	B. Russell Shaw Co.
Mac Short	Stearman Aircraft Co.
Wm. B. Stout	Stout Air Services, Inc.
E. E. Wilson	Hamilton Standard Propeller Co.
Orville Wright	Dayton, Ohio
T. P. Wright	Curtiss Aeroplane & Motor Co.

AIRCRAFT-ENGINE ACTIVITY COMMITTEE

B. G. Leighton, *Chairman*	Wright Aeronautical Corp.
H. K. Cummings	U. S. Bureau of Standards
John Geisse	Comet Engine Co.
Leigh Griffith	Emsco Aero Engine Co.
E. D. Herrick	Lycoming Mfg. Co.
Robert Insley	Continental Motors Corp.
Dr. Geo. W. Lewis	Nat'l Advisory Committee for Aeronautics
George J. Mead	Pratt & Whitney Aircraft Co.
Arthur Nutt	Curtiss Aero. & Motor Co., Inc.
Lieut. E. R. Page	U. S. Army Air Corps
Lieut. Commndr. J. M. Shoemaker	Bureau of Aeronautics, U. S. Navy
Mac Short	Stearman Aircraft Co.
Charles F. Taylor	Mass. Institute of Tech.
P. B. Taylor	Wright Aeronautical Corp.
N. N. Tilley	Kinner Airplane & Motor Corp.
L. M. Woolson	Packard Motor Car Co.

DIESEL-ENGINE ACTIVITY COMMITTEE

O. D. Treiber, *Chairman*	Treiber Diesel Engine Corp.
C. B. Jahnke, *Vice-Chairman*	Fairbanks, Morse & Co.
A. C. Attendu	Consulting Automotive Engineer, Montreal
R. J. Broege	Buda Co.
Harte Cooke	McIntosh & Seymour Corp.
F. B. Doyle	Ingersoll-Rand Co.
J. B. Frauenfelder	Sun Shipbuilding & Dry Dock Co.
N. H. Gilman	Allison Engineering Co.
L. M. Griffith	Emsco Aero Engine Co.
H. D. Hill	Hill Diesel Engine Co.
H. A. Huebotter	Waukesha Motor Co.
J. H. Hunt	General Motors Corp.
H. L. Knudsen	Cummins Engine Co.
D. W. R. Morgan	Westinghouse Electric & Mfg. Co.
J. F. Max Patitz	Allis-Chalmers Mfg. Co.
A. J. Poole	Robert Bosch Magneto Co.
J. O. Scherer	Junkers Corp. of America
P. H. Schweitzer	Pennsylvania State College
E. A. Sperry	Sperry Development Co., Inc.
H. R. Sutphen	Electric Boat Co.
L. M. Woolson	Packard Motor Car Co.

MOTOR-TRUCK AND MOTORCOACH ACTIVITY COMMITTEE

A. J. Scaife, *Chairman*	The White Co.
G. B. Ingersoll, *Vice-Chairman*	Federal Motor Truck Co.
B. B. Bachman	Autocar Co.
C. J. Bock	General Motors Truck Co.
L. R. Buckendale	Timken-Detroit Axle Co.
A. A. Bull	Handy Governor Corp.
D. S. Cole	Leece-Neville Co.
F. W. Heckert	V. G. Apple Laboratories
A. W. Herrington	Coleman Motors Corp.
M. C. Horine	International Motor Co.
B. J. Lemon	United States Rubber Co.
A. Lodge	Mohawk Chevrolet Co.
C. F. Magoffin	Reo Motor Car Co.
F. C. Patton	Los Angeles Motor Coach Co.
C. A. Peirce	Diamond T Motor Car Co.
R. S. Reed	Brockway Motor Truck Co.
A. W. Scarratt	International Harvester Co.
E. M. Schultheis	Timken Roller Bearing Co.
J. W. Shields	Firestone Tire & Rubber Co.
H. E. Simi	Twin Coach Co.
K. D. Smith	B. F. Goodrich Rubber Co.
T. C. Smith	American Telephone & Telegraph Co.
R. S. Taylor	Seattle, Wash.
A. H. Wood	General Motors Products of Canada, Ltd.

PASSENGER-CAR ACTIVITY COMMITTEE

G. L. McCain, *Chairman*	Chrysler Corp.
W. C. Keys, *Vice-Chairman*	U. S. Rubber Co.
J. R. Bartholomew	Bendix Brake Co.
G. C. Brown	Bohn Aluminum & Brass Co.
R. E. Cole	Durant Motor Co.
J. M. Crawford	Chevrolet Motor Co.
W. J. Davidson	General Motors Corp.
W. N. Davis	Cadillac Motor Car Co.
W. T. Fishleigh	Ford Motor Co.
W. R. Griswold	Packard Motor Car Co.
K. L. Herrmann	Bantam Ball Bearing Co.
L. P. Kalb	Continental Motors Corp.
F. F. Kishline	Graham-Paige Motors Corp.
B. J. Lemon	U. S. Rubber Co.
E. S. Marks	H. H. Franklin Mfg. Co.
Ivan Ornberg	Hupp Motor Car Co.
D. G. Roos	Studebaker Corp.
F. Sergardi	Reo Motor Car Co.

A. Taub	Chevrolet Motor Co.
P. L. Tenney	Muncie Products Division, General Motors Corp.

PASSENGER-CAR-BODY ACTIVITY COMMITTEE

W. N. Davis, *Chairman*	Cadillac Motor Car Co.
C. B. Parsons, *Vice-Chairman*	Parsons Co.
Ralph Adams	E. G. Budd Mfg. Co.
A. K. Brumbaugh	The White Co.
O. H. Clark	Chrysler Corp.
H. R. Crecelius	Ford Motor Co. (Lincoln Div.)
A. A. Cripps	Durant Motors, Inc.
W. H. Emond	H. H. Franklin Mfg. Co.
F. L. Faurote	New York City
K. Forbes	Buick Motor Co.
O. F. Graebner	Murray Corp. of America
R. S. Grimshaw	Griswold Motor Body Co.
Jacob Hammerl	Packard Motor Car Co.
A. DeSakhnoffsky	Hayes Body Corp.
L. C. Hill	Dietrich, Inc.
B. J. Lemon	U. S. Rubber Co.
G. L. McCain	Chrysler Corp.
A. J. Neerken	Hupp Motor Car Co.
A. Northup	Murray Corp. of America
E. G. Simpson	Fisher Body Corp.
J. W. Votypka	LeBaron-Detroit Co.

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John Younger, *Chairman*	Ohio State University
J. W. Brussel, *Vice-Chairman*	Timken-Detroit Axle Co.
J. B. Armitage	Kearney & Trecker Corp.
David Ayr	Pratt & Whitney Co.
Louis B. Berg	A. C. Spark Plug Co.
G. W. Blackinton	Sullivan Machinery Co.
E. P. Blanchard	Bullard Co.
A. K. Brumbaugh	White Motor Co.
Jack A. Callahan	Curtiss Aeroplane & Motor Co., Inc.
Jerry W. DeCou	Fageol Motors Co.
F. L. Faurote	New York City
A. R. Fors	Continental Motors Corp.
J. Geschelin	*Automotive Industries*
Lawrence J. Holmes	International Motor Co.
A. J. Langhammer	Dodge Bros. (Canada), Ltd.
C. A. Mayer	American Bosch Magneto Corp.
W. W. Nichols	D. P. Brown & Co.
Erik Oberg	*Machinery*, Industrial Press
V. P. Rumely	Hudson Motor Car Co.
E. N. Sawyer	Cleveland Tractor Co.
G. W. Smith, Jr.	White Motor Co.
F. W. Stein	Fairbanks, Morse & Co.
Clarence C. Stevens	New Departure Mfg. Co.
Edward S. Wallace	Chevrolet Motor Co.
E. W. Weaver	Trundle Engrg. Co.
Stanley Whitworth	Bendix Brake Co.

TRANSPORTATION AND MAINTENANCE ACTIVITY COMMITTEE

F. C. Horner, *Chairman*	General Motors Corp.
J. F. Winchester, *Vice-Chairman*	Standard Oil Co. of N. J.
N. D. Ballantine	Consulting Engineer, New York City
W. F. Banks	Motor Haulage Co.
Donald Blanchard	Chilton Class Journal Co.
O. M. Brede	General Motors Truck Co.
M. V. Brunson, Capt.	Quartermaster Corps (Motors), U. S. Army, Atlantic Motor Transport Pool
W. M. Clark	S. S. Pierce Co.
A. F. Coleman	Standard Oil Co. of N. Y.
H. L. Debbink	Milwaukee Elec. Ry. & Light Co.
W. J. Duffy	Big 3, Inc., Boston & Maine Trans. Co.
H. C. Eddy	State of N. J. Board of Public Utility Commissioners
E. Favary	Moreland Motor Truck Co.
A. D. Ferguson	Canadian National Railways
R. E. Fielder	General Motors Truck Co.
N. A. Finch, Jr.	General Motors Export Corp.
F. K. Glynn	American Tel. & Tel. Co.
A. H. Gossard	Middlewest Utilities Co.
Adrian Hughes, Jr.	United Railways & Elec. Co. of Baltimore
I. A. Hungerford	Borden's Farm Products Co., Inc.
T. S. Kemble	Consulting Engineer, St. Louis
A. A. Lyman	Public Service Coordinated Transport, Newark, N. J.
A. S. McArthur	Toronto Transportation Commission
H. V. Middleworth	Consolidated Gas Co.
L. H. Palmer	Fifth Ave. Coach Co.
E. S. Pardoe	Capital Traction Co., Washington, D. C.
R. E. Plimpton	*Bus Transportation*, McGraw-Hill Publishing Co.
G. O. Pooley	Chesapeake & Potomac Telephone Co. & Associated Companies
Eugene Power	Union Oil Co. of California
T. L. Preble	Brockway Motor Truck Corp.
P. V. C. See	Northern Ohio Power & Light Co.
Pierre Schon	General Motors Truck Co.
C. R. Skinner, Jr.	New York Edison Co.
E. W. Templin	Graham Bros. Division, Chrysler Corp.
E. C. Wood	Pacific Gas & Elec. Co.

Technical Committees

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F. F. Chandler	Ross Gear & Tool Co.
H. M. Crane	General Motors Corp.
H. C. Dickinson	Bureau of Standards
E. R. Hewitt	International Motor Co.
H. L. Horning	Waukesha Motor Co.
H. A. Huebotter	Waukesha Motor Co.
J. C. Hunsaker	Goodyear-Zeppelin Corp.
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H. M. Jacklin	Purdue University
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F. Jehle	White Motor Co.
C. F. Kettering	General Motors Corp.
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Benjamin Liebowitz	New York City
Neil MacCoull	The Texas Co.
G. L. McCain	Chrysler Corp.
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D. G. Roos	Studebaker Corp.
V. P. Rumely	Hudson Motor Car Co.
W. R. Strickland	Cadillac Motor Car Co.

Alex Taub	Chevrolet Motor Co.
C. F. Taylor	Massachusetts Institute of Technology
O. D. Treiber	Treiber Diesel Engine Co.
W. G. Wall	Consulting Engineer, Indianapolis
F. E. Watts	Hupp Motor Car Corp.
R. E. Wilson	Standard Oil Co. of Indiana
J. F. Winchester	Standard Oil Co. of New Jersey
A. M. Wolf	Consulting Engineer, Newark, N. J.
H. T. Woolson	Chrysler Corp.
L. M. Woolson	Packard Motor Car Co.

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B. J. Lemon, *Chairman*	United States Rubber Co.
W. B. Barnes	Auburn Automobile Co.
F. F. Chandler	Ross Gear & Tool Co.
C. P. Grimes	Grimes Brake Engineering Service
Newton Hadley	Chrysler Corp.
O. T. Kreusser	Fisher Body Corp.
E. S. Marks	H. H. Franklin Mfg. Co.
J. M. Nickelsen	University of Michigan
A. R. Platt	A. R. Platt Automobile Repairs

FUELS SUBCOMMITTEE

(Cooperating with the National Automobile Chamber of Commerce, the American Petroleum Institute and the American Society for Testing Materials)

Neil MacCoull, *Chairman*	The Texas Co.
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B. B. Bachman	Autocar Co.
D. P. Barnard	Standard Oil Co. of Indiana
A. L. Beall	Vacuum Oil Co.
A. E. Becker	Standard Oil Development Co.
O. C. Berry	Marvel Carburetor Co.
T. A. Boyd	General Motors Corp.
G. G. Brown	University of Michigan
H. R. Cobleigh	National Automobile Chamber of Commerce
H. M. Crane	General Motors Corp.
C. L. Cummins	Cummins Engine Co.
H. C. Dickinson	Bureau of Standards
C. S. Fliedner	Bureau of Aeronautics, Navy Department
J. Barraja Frauenfelder	Sun Shipbuilding & Dry Dock Co.
L. M. Griffith	Emsco Aero Engine Co.
S. D. Heron	Air Corps
H. L. Horning	Waukesha Motor Co.
H. A. Huebotter	Waukesha Motor Co.
J. H. Hunt	General Motors Corp.
C. B. Jahnke	Fairbanks, Morse & Co.
W. S. James	Studebaker Corp.
W. F. Joachim	Westinghouse Electric & Mfg. Co.
L. P. Kalb	Continental Motors Corp.
C. S. Kegerreis	Tillotson Mfg. Co.
J. B. Macauley	Chrysler Corp.
F. C. Mock	Bendix Aviation Corp.
Arthur Nutt	Curtiss Aeroplane & Motor Co., Inc.
T. B. Rendel	Shell Petroleum Corp.
Daniel Roesch	Armour Institute of Technology
C. D. Salisbury	Winton Engine Co.
P. H. Schweitzer	Pennsylvania State College
Wesley Smith	National Air Transport, Inc.
S. W. Sparrow	Studebaker Corp.
E. A. Sperry	Sperry Development Co., Inc.
C. F. Taylor	Massachusetts Institute of Technology
O. D. Treiber	Treiber Diesel Engine Corp.
J. E. Wild	Robert Bosch Magneto Co., Inc.
J. F. Winchester	Standard Oil Co. of New Jersey
L. M. Woolson	Packard Motor Car Co.

HEADLIGHT SUBCOMMITTEE

H. M. Crane, *Chairman*	General Motors Corp.
C. C. Bohner	Tung-Sol Lamp Works, Inc.
R. E. Carlson	Westinghouse Lamp Co.
H. C. Dickinson	Bureau of Standards
R. N. Falge	General Motors Corp.
W. T. Fishleigh	Ford Motor Co.
J. H. Hunt	General Motors Corp.
E. E. Huntington	Willys-Overland Co.
W. M. Johnson	National Lamp Works of General Electric Co.
P. J. Kent	Chrysler Corp.
E. S. Marks	H. H. Franklin Mfg. Co.
C. A. Michel	Guide Lamp Co.
John Warner	Studebaker Corp.

HIGHWAYS SUBCOMMITTEE

(Cooperating with the Rubber Association of America and the U. S. Bureau of Public Roads)

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B. B. Bachman	Autocar Co.
R. W. Brown	Firestone Tire & Rubber Co.
W. E. Lay	University of Michigan
B. J. Lemon	United States Rubber Co.
Benjamin Liebowitz	New York City
E. H. Lockwood	Yale University
J. A. Sloan	Mack Trucks Inc.
J. F. Winchester	Standard Oil Co. of New Jersey

RIDING-COMFORT SUBCOMMITTEE

R. W. Brown, *Chairman*	Firestone Tire & Rubber Co.
Frank Born	Wahl Co.
F. F. Chandler	Ross Gear & Tool Co.
W. J. Davidson	General Motors Corp.
H. C. Dickinson	Bureau of Standards
M. L. Fox	Houde Engineering Corp.
Tore Franzen	Chrysler Corp.
Samuel P. Hess	Detroit Steel Products Co.
H. M. Jacklin	Purdue University
W. S. James	Studebaker Corp.
B. J. Lemon	United States Rubber Co.
Benjamin Liebowitz	New York City
Orrel A. Parker	Parker Wheel Co.
R. F. Peo	Houde Engineering Corp.
W. C. Robbins	Gabriel Snubber Co.
E. F. Rossman	Delco Products Co.
W. R. Strickland	Cadillac Motor Car Co.
W. G. Wall	Consulting Engineer, Indianapolis
John Warner	Studebaker Corp.

COOPERATIVE FUEL RESEARCH STEERING COMMITTEE

(Cooperating with the National Automobile Chamber of Commerce and the American Petroleum Institute)

B. B. Bachman	Autocar Co.
O. C. Berry	Marvel Carburetor Co.
T. A. Boyd	General Motors Corp.
H. R. Cofleigh	National Automobile Chamber of Commerce
H. M. Crane	General Motors Corp.
H. C. Dickinson	Bureau of Standards
H. L. Horning	Waukesha Motor Co.
W. S. James	Studebaker Corp.
L. P. Kalb	Continental Motors Corp.

C. S. Kegerreis	Tillotson Mfg. Co.
J. B. Macauley	Chrysler Corp.
F. C. Mock	Bendix Aviation Corp.
Daniel Roesch	Armour Institute of Technology
Wesley Smith	National Air Transport, Inc.

SPECIAL RESEARCH COMMITTEE ON MECHANICAL SPRINGS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

N. E. Hendrickson	Mather Spring Co.
Benjamin Liebowitz	New York City
E. W. Stewart	Wm. D. Gibson Co.

COOPERATIVE COMMITTEE ON MOTOR-TRUCK IMPACT TESTS

(Cooperating with the U. S. Bureau of Public Roads and the Rubber Association of America)

B. B. Bachman	Autocar Co.
Benjamin Liebowitz	New York City
C. B. Veal	Society of Automotive Engineers, Inc.

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G. L. McCain, *Vice-Chairman*	Chrysler Corp.
C. A. Michel, *Vice-Chairman*	Guide Lamp Corp.

AIRCRAFT DIVISION

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Mac Short, *Vice-Chairman*	Stearman Aircraft Co.
Don M. Alexander	Alexander Aircraft Co.
L. M. Bach	Bach Aircraft Co., Inc.
H. A. Backus	Berliner-Joyce Aircraft Corp.
R. S. Barnaby	Bureau of Aeronautics, Navy Dept.
John R. Cautley	Bendix Brake Co.
G. G. Emerson	Wright Aeronautical Corp.
Flight-Lieut. A. Ferrier	Canadian Department of National Defence
Lieut. C. B. Harper	Bureau of Aeronautics, Navy Dept.
H. A. Hicks	Stout Metal Airplane Co., Div. of Ford Motor Co.
Maj. C. W. Howard	Materiel Division, Air Corps
I. M. Laddon	Consolidated Aircraft Corp.
K. M. Lane	Aeronautics Branch, Dept. of Commerce
B. J. Lemon	United States Rubber Co.
C. J. McCarthy	Chance Vought Corp.
Leslie MacDill	Army Air Corps
J. W. Musser	Aero Supply Mfg. Co., Inc.
C. T. Porter	Keystone Aircraft Corp.
L. D. Seymour	National Air Transport, Inc.
Gerard Vultee	Lockheed Aircraft Co.
Edward Wallace	Great Lakes Aircraft Corp.
E. E. Wilson	Hamilton Standard Steel Propeller Co.
T. P. Wright	Curtiss Aeroplane & Motor Co., Inc.

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Arthur Nutt, *Chairman*	Curtiss Aeroplane & Motor Co., Inc.
L. M. Griffith, *Vice-Chairman*	Emsco Aero Engine Co.
Roland Chilton	Wright Aeronautical Corp.
Edward D. Herrick	Lycoming Mfg. Co.
Robert Insley	Continental Motors Corp.
Ludwig A. Majneri	Warner Aircraft Corp.
G. J. Mead	Pratt & Whitney Aircraft Co.
Lieut. E. R. Page	Materiel Division, Air Corps
Commander J. M. Shoemaker	Bureau of Aeronautics, Navy Dept.
L. M. Woolson	Packard Motor Car Co.

AXLE AND WHEELS DIVISION

O. A. Parker, *Chairman*	Parker Wheel Co.
George Walther, *Vice-Chairman*	Dayton Steel Foundry Co.
L. R. Buckendale	Timken-Detroit Axle Co.
G. W. Carlson	Eaton Axle & Spring Co.
C. C. Carlton	Motor Wheel Corp.
G. W. Harper	Columbia Axle Co.
E. R. Jacobi	Kelsey-Hayes Wheel Corp.

BALL AND ROLLER-BEARINGS DIVISION

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E. R. Carter, Jr., *Vice-Chairman*	Fafnir Bearing Co.
H. E. Brunner	S K F Industries, Inc.
F. H. Buhlman	Rollway Bearing Co., Inc.
D. F. Chambers	The Bearings Co. of America
L. A. Cummings	Marlin-Rockwell Corp.
T. C. Delaval-Crow	New Departure Mfg. Co.
H. R. Gibbons	Hyatt Bearings Division, General Motors Corp.
K. L. Herrmann	Bantam Ball Bearing Co.
H. N. Parsons	Strom Bearings Co.
Ernest Wooler	Timken Roller Bearing Co.

DIESEL-ENGINE DIVISION

C. B. Jahnke, *Chairman*	Fairbanks, Morse & Co.
D. W. R. Morgan, *Vice-Chairman*	Westinghouse Elec. & Mfg. Co.
R. J. Broege	Buda Co.
Harte Cooke	McIntosh & Seymour Corp.
C. L. Cummins	Cummins Engine Co.
J. F. Fox	U. S. Navy Yard
H. D. Hill	Hill Diesel Engine Co.
H. A. Huebotter	Waukesha Motor Co.
E. Nibbs	Electric Boat Co.
A. J. Poole	Robert Bosch Magneto Co.
E. B. Rawlins	Cooper-Bessemer Co.
O. D. Treiber	Trieber Diesel Engine Corp.
L. M. Woolson	Packard Motor Car Co.

ELECTRICAL EQUIPMENT DIVISION

D. M. Pierson, *Chairman*	Chrysler Corp.
D. S. Cole, *Vice-Chairman*	Leece-Neville Co.
Azel Ames	Kerite Insulated Wire & Cable Co., Inc.
A. K. Brumbaugh	White Motor Co.
W. S. Haggott	Packard Electric Co.
L. M. Kanters	Waukesha Motor Co.
T. L. Lee	North East Appliance Corp.
A. R. Lewellen	Chevrolet Motor Co.
L. E. Lighton	Electric Storage Battery Co.
L. O. Parker	Delco-Remy Corp.
E. K. Schadt	Cadillac Motor Car Co.
T. E. Wagar	Studebaker Corp.

GASOLINE-ENGINE DIVISION

E. S. Marks, *Chairman*	H. H. Franklin Mfg. Co.
J. B. Fisher, *Vice-Chairman*	Waukesha Motor Co.
Paul C. Bastien	General Motors Corp., Olds Motor Works
R. J. Broege	Buda Co.
E. D. Herrick	Lycoming Mfg. Co.
L. P. Kalb	Continental Motors Corp.
E. T. Larkin	Sterling Engine Co.
A. F. Milbrath	Wisconsin Motor Mfg. Co.

H. G. Smith	Hercules Motor Corp.
R. R. Teetor	Perfect Circle Co.
V. C. Young	International Motor Co.

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R. J. Allen	Rolls-Royce of America, Inc.
A. L. Boegehold	General Motors Corp. Research Laboratories
Henry Chandler	Vanadium Corp. of America
B. H. DeLong	Carpenter Steel Co.
F. P. Gilligan	Henry Souther Engrg. Corp.
H. W. Graham	Jones & Laughlin Steel Corp.
H. L. Greene	Willys-Overland, Inc.
W. G. Hildorf	Timken Steel & Tube Co.
E. J. Janitzky	Illinois Steel Co.
W. J. MacKenzie	Interstate Iron & Steel Co.
J. A. Mathews	Crucible Steel Co. of America
W. C. Peterson	Donner Steel Co.
E. A. Portz	Central Alloy Steel Corp.
S. P. Rockwell	Stanley P. Rockwell Co.
R. B. Schenck	Buick Motor Co.
H. P. Tiemann	Carnegie Steel Co.
E. W. Upham	Chrysler Corp.
T. H. Wickenden	International Nickel Co.
Henry Wysor	Bethlehem Steel Co.
O. B. Zimmerman	International Harvester Co.

LIGHTING DIVISION

C. A. Michel, *Chairman*	Guide Lamp Corp.
R. E. Carlson, *Vice-Chairman*	Westinghouse Lamp Co.
Clyde C. Bohner	Tung-Sol Works
A. W. Devine	Massachusetts Registry of Motor Vehicles
H. C. Doane	Buick Motor Co.
G. P. Doll	Thos. J. Corcoran Lamp Co.
R. N. Falge	General Motors Corp. Research Laboratories
W. S. Hadaway	Edison Lamp Works, General Electric Co.
C. L. Holm	Ford Motor Co.
R. W. Johnson	John W. Brown Mfg. Co.
W. M. Johnson	National Lamp Works of the General Electric Co.
A. R. Lewellen	Chevrolet Motor Co.
A. L. Martinek	C. M. Hall Lamp Co.
D. M. Pierson	Chrysler Corp.
W. F. Thoms	Allied Products Corp.
T. E. Wagar	Studebaker Corp.

LUBRICANTS DIVISION

E. W. Upham, *Chairman*	Chrysler Corp.
H. C. Mougey, *Vice-Chairman*	General Motors Corp. Research Laboratories
Sydney Bevin	Tide Water Oil Co.
A. B. Boehm	Standard Oil Co. of New Jersey
O. E. Eckert	Independent Oil & Gas Co.
J. B. Fisher	Waukesha Motor Co.
J. C. Geniesse	The Atlantic Refining Co.
W. H. Graves	Packard Motor Car Co.
E. N. Klemgard	Shell Oil Co.
C. M. Larson	Sinclair Refining Co.
K. G. Mackenzie	The Texas Co.
W. H. Oldacre	D. A. Stuart & Co., Ltd.
W. F. Parish	New York City
G. A. Round	Vacuum Oil Co.
H. J. Saladin	Standard Oil Co. of Indiana
W. A. P. Schorman	British American Oil Co., Ltd.
F. D. Shields	Transcontinental Oil Co.
B. E. Sibley	Continental Oil Co.
C. W. Simpson	White Motor Co.
H. G. Smith	Gulf Refining Co.
J. B. Terry	Standard Oil Co. of California
R. E. Wilson	Standard Oil Co. of Indiana

MOTORBOAT AND MARINE-ENGINE DIVISION

Leonard Ochtman, Jr., *Chairman*	Elco Works, Electric Boat Co.
N. E. Donnelly, *Vice-Chairman*	Dawn Boat Corp.
W. R. Beckman	Johnson Motor Co.
C. T. Chenevert	Corsaire Boat Co.
James Craig	National Association of Engine & Boat Manufacturers
K. L. Childs	Auto-Hydro-Craft, Inc.
Jacob Dunnell	Ludington Aircraft, Inc.
Frank Fernstrum	Gray Marine Motor Co.
H. E. Fromm	Chrysler Sales Corp.
Geo. N. Hickey	Kermath Mfg. Co.
F. T. Irgens	Outboard Motors Corp.
S. Clyde Kyle	American Car & Foundry Co.
V. E. Lacy	Rochester Boat Corp.
R. G. Lane	Indian Motocycle Co.
Walter Le Veau	Horace E. Dodge Boat Works
A. E. Luders	Luders Marine Construction Co.
Howard W. Lyon	Howard W. Lyon, Inc.
Harry Masoner Representative	Caille Perfection Motor Co. Gar Wood, Inc.

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Adolph Gelpke, *Vice-Chairman*	Autocar Co.
W. J. Baumgartner	Relay Motors Corp.
M. C. Horine	International Motor Co.
L. C. Josephs, Jr.	International Motor Co.
F. W. Kateley	American Car & Foundry Motors Co.
W. F. Klein	General Motors Truck Co.
A. A. Lyman	Public Service Coordinated Transport
J. A. Packard	Studebaker Corp.
L. H. Palmer	Fifth Avenue Coach Co.
A. J. Scaife	The White Co.
E. M. Schultheis	Timken Roller Bearing Co.
P. V. C. See	Northern Ohio Power & Light Co.
Ernest M. Sternberg	Sterling Motor Truck Co.

NON-FERROUS METALS DIVISION

Zay Jeffries, *Chairman*	Aluminum Co. of America
C. W. Simpson, *Vice-Chairman*	White Motor Co.
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W. H. Bassett	American Brass Co.
C. H. Calkins	Baush Machine Tool Co.
D. L. Colwell	Stewart Die Casting Corp.
H. R. Corse	Lumen Bearing Co.
W. A. Cowan	National Lead Co. Research Laboratories
R. M. Curts	New Jersey Zinc Co.
P. V. Faragher	Aluminum Co. of America
W. H. Graves	Packard Motor Car Co.
H. L. Greene	Willys-Overland, Inc.
J. B. Johnson	Materiel Division, Air Corps
R. R. Moore	Wright Aeronautical Corp.
H. C. Mougey	General Motors Corp. Research Laboratories
A. L. Nelson	Bohn Aluminum & Brass Corp.

W. B. Price	Scovill Mfg. Co.
T. H. Wickenden	International Nickel Co.
H. M. Williams	Frigidaire Corp.

PARTS AND FITTINGS DIVISION

A. Boor, *Chairman*	Willys-Overland Co.
Ivan Ornberg, *Vice-Chairman*	Hupp Motor Car Corp.
A. K. Brumbaugh	White Motor Co.
D. E. Gamble	Borg & Beck Co.
R. V. Hutchinson	Olds Motor Works
H. S. Jandus	General Spring Bumper Corp.
W. C. Keys	United States Rubber Co.
G. L. McCain	Chrysler Corp.
M. B. Morgan	Timken-Detroit Axle Co.
W. J. Outcalt	General Motors Corp.
C. W. Spicer	Spicer Mfg. Corp.
C. E. Swenson	Mechanics Universal Joint Co.
P. L. Tenney	Muncie Products Division, General Motors Corp.
S. O. White	Warner Gear Co.
F. G. Whittington	Evanston, Ill.
G. W. Yanss	Eastwood Wire Corp.
O. B. Zimmerman	International Harvester Co.

PASSENGER-CAR DIVISION

G. L. McCain, *Chairman*	Chrysler Corp.
L. A. Chaminade, *Vice-Chairman*	Studebaker Corp.
W. L. Barth	General Motors Corp.
S. R. Castor	H. H. Franklin Mfg. Co.
W. N. Davis	Cadillac Motor Car Co.
G. A. Delaney	Graham-Paige Motors Corp.
W. T. Fishleigh	Ford Motor Co.
B. J. Lemon	United States Rubber Co.
Ivan Ornberg	Hupp Motor Car Corp.
H. C. Snow	Auburn Automobile Co.

PRODUCTION DIVISION

F. W. Stein, *Chairman*	Fairbanks, Morse & Co.
A. R. Fors, *Vice-Chairman*	Continental Motors Corp.
David Ayr	Pratt & Whitney Co.
F. P. Barnes	Hupp Motor Car Corp.
M. H. Blank	White Motor Co.
Guy M. Hartsock	Studebaker Corp.
C. A. Mayer	American Bosch Magneto Corp.
W. P. Michell	International Motor Co.
D. W. Ovaitt	Buick Motor Co.
L. L. Roberts	Packard Motor Car Co.
E. N. Sawyer	Cleveland Tractor Co.
Stanley Whitworth	Bendix Brake Co.

SCREW-THREADS DIVISION

E. H. Ehrman, *Chairman*	Standard Screw Co.
Earle Buckingham, *Vice-Chairman*	Massachusetts Institute of Technology
A. Boor	Willys-Overland Co.
E. J. Bryant	Greenfield Tap & Die Corp.
Ellwood Burdsall	Russell, Burdsall & Ward Bolt & Nut Co.
L. D. Burlingame	Brown & Sharpe Mfg. Co.
G. S. Case	Lamson & Sessions Co.
R. M. Heames	Victor Peninsular Division, Allied Products Corp.
W. J. Outcalt	General Motors Corp.
L. L. Roberts	Packard Motor Car Co.
S. B. Terry	Pratt & Whitney Co.
O. B. Zimmerman	International Harvester Co.

TIRE AND RIM DIVISION

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W. R. Griswold, *Vice-Chairman*	Packard Motor Car Co.
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R. S. Begg	Stutz Motor Car Co. of America, Inc.
C. E. Bonnett	Tire & Rim Association of America
C. C. Carlton	Motor Wheel Corp.
L. A. Chaminade	Studebaker Corp.
B. Darrow	Goodyear Tire & Rubber Co.
E. E. Dearth	Fisk Rubber Co.
W. T. Fishleigh	Ford Motor Co.
J. E. Hale	Firestone Tire & Rubber Co.
F. W. Hertrich	Buick Motor Co.
F. M. Holden	Oakland Motor Car Co.
H. W. Kranz	Cleveland Welding Co.
B. J. Lemon	United States Rubber Co.
E. S. Marks	H. H. Franklin Mfg. Co.
W. B. Minch	Jaxon Steel Products Division, General Motors Corp.
Maurice Olley	Rolls-Royce of America, Inc.
G. E. Parker	Cadillac Motor Car Co.
A. J. Scaife	The White Co.
K. D. Smith	B. F. Goodrich Co.
J. G. Swain	Goodyear Tire & Rubber Co., Inc.
C. P. Thomas	Reo Motor Car Co.
L. Thoms	Graham-Paige Motors Corp.
F. E. Watts	Hupp Motor Car Corp.
B. F. Wright	Chrysler Sales Corp.
R. B. Wuerfel	Chevrolet Motor Co.

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G. S. Case	Lamson & Sessions Co.
E. H. Ehrman	Standard Screw Co.

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Lloyd Blackmore	General Motors Corp.
R. A. Brannigan	National Automobile Chamber of Commerce

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H. M. Crane	General Motors Corp.
J. H. Hunt	General Motors Corp.
A. J. Scaife	The White Co.
W. G. Wall	Indianapolis
E. P. Warner	McGraw-Hill Publishing Co., Inc.

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AERONAUTICAL SAFETY CODE[1]

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Archibald Black	Black & Bigelow, Inc.
V. E. Clark	Aviation Corp.
G. L. Martin	Glenn L. Martin Co.
G. J. Mead	Pratt & Whitney Aircraft Co.
I. M. Uppercu	Uppercu-Cadillac Corp.
R. H. Upson	Red Bank, N. J.
T. P. Wright	Curtiss Aeroplane & Motor Co., Inc.

BALL BEARINGS[1]

F. W. Gurney, *Chairman*	Marlin-Rockwell Corp.
R. S. Burnett, *Secretary*	Society of Automotive Engineers, Inc.
F. L. Brown	White Motor Co.
H. E. Brunner	S. K. F. Industries, Inc.
L. A. Cummings	Marlin-Rockwell Corp.
F. G. Hughes	New Departure Mfg. Co.

[1] Sponsored by the Society.

BOLT, NUT AND RIVET PROPORTIONS[1]

J. A. Anglada	Anglada Motor Corp.
A. Boor	Willys-Overland Co.
A. H. Gilbert	Rock Island Plow Co.
M. C. Horine	International Motor Co.
W. J. Outcalt	General Motors Corp.

BRAKES AND BRAKE TESTING[2]

J. R. Cautley	Bendix Brake Co.
R. E. Fielder	General Motors Truck Co.

DRAWINGS AND DRAFTING ROOM PRACTICE[2]

M. C. Frins	International Motor Co.
C. F. Drumm (*Alternate*)	International Motor Co.

ELECTRIC WELDING[2]

Alexander Churchward	Wilson Welder & Metals Co.

GEARS[2]

Earle Buckingham	Massachusetts Institute of Technology
P. L. Tenney	Muncie Products Division, General Motors Corp.

INSULATED WIRE AND CABLE[2]

F. W. Andrew	Tacony, Pa.
W. S. Haggott	Packard Electric Co.

MACHINE PINS[1]

W. J. Outcalt	General Motors Corp.
O. B. Zimmerman	International Harvester Co.

MACHINE-TOOL SAFETY-CODE[2]

A. J. Gifford	Leland-Gifford Co.

MOTOR-VEHICLE LIGHTING SPECIFICATIONS[1]

H. M. Crane	General Motors Corp.
T. J. Litle, Jr.	Holley Carburetor Co.
C. A. Michel	Guide Lamp Corp.
A. J. Scaife	White Co.
P. V. C. See	Northern Ohio Power & Light Co.

PIPE THREADS[2]

Joseph Berge	Crowner Co.

PLAIN AND LOCK WASHERS[1]

B. M. Smarr	General Motors Corp.
W. J. Outcalt (*Alternate*)	General Motors Corp.
A. Boor	Willys-Overland Co.
O. B. Zimmerman	International Harvester Co.

PLAIN LIMIT-GAGES AND GAGING SYSTEMS[2]

P. W. Abbott	Studebaker Corp.
D. W. Ovaitt	Buick Motor Co.

SAFETY CODE FOR MECHANICAL POWER TRANSMISSION APPARATUS[2]

W. W. Nichols	D. P. Brown & Co.
E. N. Sawyer	Cleveland Tractor Co.
C. W. Spicer	Spicer Mfg. Corp.
F. W. Stein	Fairbanks, Morse & Co.

SCIENTIFIC AND ENGINEERING SYMBOLS AND ABBREVIATIONS[2]

R. M. Anderson	Stevens Institute of Technology
E. P. Warner (*Alternate*)	McGraw-Hill Publishing Co., Inc.

SCREW THREADS[1]

A. Boor	Willys-Overland Co.
Earle Buckingham	Massachusetts Institute of Technology
G. S. Case	Lamson & Sessions Co.
E. H. Ehrman	Standard Screw Co.
O. B. Zimmerman	International Harvester Co.

SHAFTING[2]

C. W. Spicer	Spicer Mfg. Corp.

SMALL TOOLS AND MACHINE-TOOL ELEMENTS[1]

J. A. Anglada	Anglada Motor Corp.
Earle Buckingham	Massachusetts Institute of Technology
D. W. Ovaitt	Buick Motor Co.

STANDARDIZATION OF ELECTRIC MOTOR FRAME DIMENSIONS[2]

J. A. Kreis	Hupp Motor Car Corp.

STANDARDIZATION OF SPEEDS OF DRIVEN MACHINES[2]

J. A. Kreis	Hupp Motor Car Corp.

STANDARDIZATION OF STOCK SIZES, SHAPES, AND LENGTHS OF HOT AND COLD-FINISHED IRON AND STEEL BARS

A. L. Boegehold	General Motors Corp.

SUBCOMMITTEE ON WOODRUFF KEYS

K. L. Herrmann	Bantam Ball Bearing Co.
D. W. Ovaitt	Buick Motor Co.
C. W. Spicer	Spicer Mfg. Corp.

TRANSMISSION CHAINS AND SPROCKETS[1]

W. J. Belcher	Whitney Mfg. Co.
W. F. Cole	Baldwin Chain & Mfg. Co.
M. C. Horine	International Motor Co.
G. A. Young	Purdue University
O. B. Zimmerman	International Harvester Co.

USE, CARE AND PROTECTION OF ABRASIVE WHEELS[2]

A. J. Gifford	Leland-Gifford Co.

WIRE AND SHEET-METAL GAGING SYSTEMS[1]

W. H. Hutchins	North East Appliance Corp.
B. M. Leece	Leece-Neville Co.
W. J. Outcalt	General Motors Corp.
F. G. Whittington	Evanston, Ill.

ZINC COATING OF IRON AND STEEL[2]

W. H. Hutchins	North East Appliance Corp.
W. M. Phillips	General Motors Corp.
W. B. Stout	Stout Air Services, Inc.

Advisory Committees

ORDNANCE ADVISORY COMMITTEE

A. F. Masury, *Chairman*	International Motor Co.
H. W. Alden	Timken-Detroit Axle Co.
George A. Green	Yellow Truck & Coach Mfg. Co.
F. C. Hecox	Cadillac Motor Car Co.
A. W. Herrington	Coleman Motors Corp.
P. E. Holt	Caterpillar Tractor Co.
E. F. Norelius	Monarch Tractors Corp.
G. A. Round	Vacuum Oil Co.
W. G. Wall	Indianapolis
J. F. Winchester	Standard Oil Co. of N. J.
A. J. Scaife	White Motor Co.

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T. J. Litle, Jr., *Chairman*	Marmon Motor Car Co.
F. S. Duesenberg	Duesenberg, Inc.
A. W. Herrington	Coleman Motors Corp.
C. S. Ricker	Waukesha Motor Co.
D. G. Roos	Studebaker Corp.
H. C. Snow	Auburn Automobile Co.
W. G. Wall	Indianapolis
L. M. Woolson	Packard Motor Car Co.

[1] Sponsored by the Society.
[2] The Society does not sponsor but is represented on this Sectional Committee.

S.A.E. Representatives on Other Organizations and Committees

Advisory Board of the Government Technical Committee on Lubricants and Liquid Fuels

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Advisory Board on Dictionary of Government Specifications

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R. S. Burnett	Society of Automotive Engineers, Inc.

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American Society for Testing Materials Committee A-1 and Its Subcommittee X on Automobile Steels

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American Society for Testing Materials Committee A-7 on Malleable Iron

H. T. Chandler	Vanadium Corp. of America

American Society for Testing Materials Committee D-2 on Oils

H. C. Mougey	General Motors Corp.

American Society for Testing Materials Committee XIV on Tool Steel of Committee A-1 on Steel

A. H. D'Arcambal	Pratt & Whitney Co.

American Society for Testing Materials Joint Committee on Investigation of Phosphorus and Sulphur in Steel

F. P. Gilligan	Henry Souther Engineering Co.

American Society for Testing Materials Subcommittee D-11 on Rubber Products

L. C. Conradi	Lycoming Mfg. Co.

American Society for Testing Materials Subcommittee XII on Methods of Chemical Analysis of Committee A-1 on Steels

J. R. Adams	Midvale Co.

American Society for Testing Materials Subcommittee XV on Die-Casting Metals and Alloys of Committee B-2

C. W. Simpson	White Motor Co.

American Society for Testing Materials Subcommittee XIX on Sheet Steel of Committee A-1 on Steels

W. C. Peterson	Donner Steel Co.

American Standards Association, Board of Directors

F. E. Moskovics	Improved Products Co.

American Standards Association, Standards Council

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A. J. Scaife, alternate	White Motor Co.

American Standards Association Committee on Form and Arrangement of Specifications

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Committee on Ferrous Metals

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Committee on Motorcoaches of the American Electric Railway Association

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National Research Council Engineering and Industrial Division

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National Screw-Thread Commission

Earle Buckingham	Massachusetts Institute of Technology
George S. Case	Lamson and Session Co.

Powerplant Subcommittee of National Advisory Committee for Aeronautics

H. M. Crane	General Motors Corp.

Reports of Society Committees, 1929

Membership Committee

The Membership Committee takes pleasure in presenting the following membership figures for the last year, believing that they show a growth commensurate with the increased activities and scope of the Society work.

	Year Ended Dec. 31		
	1929	1928	1927
Applications for Membership Received	1,214	1,058	929
Percentage of Applicants Qualifying, per cent	66	68	70
Membership by Grades			
Members (including Foreign and Service)	3,690	3,511	3,284
Associates	2,237	2,088	1,960
Juniors	652	595	560
Affiliates	112	110	110
Total Members	6,691	6,304	5,914
Affiliate Member Representatives	181	183	191
Enrolled Students	355	434	355
Grand Total	7,227	6,921	6,460

The Membership Committee takes this opportunity to express its sincere appreciation to the Sections and to the individual members of the Society who have assisted in the work and made such a growth possible.

E. F. LOWE,
Chairman.

Publication Committee

In the calendar year 1929 a marked increase in the number of National meeting papers published in the S.A.E. JOURNAL was recorded, accompanied by a slight decrease in the number of pages of text. In many instances the discussions were published with the papers, thus reducing by nearly one-half the number of discussions published separately subsequently to the publication of the respective papers. The total number of pages for the year increased approximately 4 per cent over 1928; the percentage of text pages decreasing approximately 3 per cent. The following table indicates the volume of material published in the S.A.E. JOURNAL for the last two calendar years:

	1928	1929
Total Pages, Text and Advertisements	2,926	3,040
Total Text Pages	1,510	1,495
Percentage of Text	52	49
National Meeting Papers Published	58	76
Section Meeting Papers Published	38	38
Separate Discussions Published	23	14
Contributed Articles Published	0	1

At the Semi-Annual Meeting last June the Council authorized increasing the number of text pages in the S.A.E. JOURNAL to provide for publishing more meetings papers and discussion. During the last four months of 1929 there has been an average increase of 26 pages of papers and discussion per issue over that of the same period of 1928.

The last of the semi-annual and the first of the yearly volumes of S.A.E. TRANSACTIONS were published last year. Part II of TRANSACTIONS for 1927 was issued during the spring, and Vol. 23, covering the entire year of 1928, was issued late in the autumn. The present plan is to bring out one volume each year, this to be issued in the spring. With the adoption of the yearly basis of publication for TRANSACTIONS, a blank was placed on the dues bills sent out on Oct. 1, whereby the members could indicate whether they desire to receive the volume to be issued during the present fiscal year. This practice is to be followed annually hereafter.

JOHN YOUNGER,
Chairman.

Production Committee

The Production Committee of the Society was continued in 1929 but no regular Committee meetings were held, its work having been carried on mainly by correspondence and by conference with Production-Committee Chairman E. P. Blanchard and other members of the Committee and with other production engineers of the industry.

The Subcommittees or groups of the Production Committee that were appointed at the beginning of the administrative year were:

Group I—Material Handling
Group II—Processes and Equipment
Group III—Time Study and Personnel Relations
Group IV—Production Expense (Cost and Budgeting)
Group V—Production Standards
Group VI—Inspection Methods
Group VII—Sections Activities
Group VIII—Technical Programs (Meetings)

The principal activity of the Committee related to the discussion of programs for the National Production Meeting that was held in October at Cleveland and subjects for papers at production sessions at other National meetings and at Section meetings. An informal conference of production executives was held in June at Detroit at which a number of subjects of general importance to production engineers were discussed. The Technical Program Subcommittee or group, with the cooperation of Chairman Blanchard, subsequently developed the program for the Production Meeting at Cleveland in October in conjunction with the National Machine Tool Exhibition and Congress. The meeting consisted of two evening sessions during the week, following two similar sessions arranged by the American Society of Mechanical Engineers, and a Production Dinner planned jointly by the Cleveland Sections of the Society and the A. S. M. E. as hosts and with the cooperation of the National Machine Tool Builders Association.

During the year the Production Engineering department of the S.A.E. JOURNAL was continued in all 12 issues, a total of 21 production articles being published in this department. In addition, 14 technical production papers and other technical papers bearing on production matters were published in THE JOURNAL during the year.

There was considerable activity during 1929 in production engineering standardization, although the Production Committee as such took part in this work only indirectly by reviewing reports and furnishing criticisms and suggestions to the standardizing committees. This phase of the work is referred to in the report of the Standards Committee for the year.

With the Production Committee continuing this year, under the recently adopted plan of official recognition by the Council of professional activities, and with increasing membership of production engineers in the Society, it is hoped that greater interest and activity in production matters will be stimulated by National meetings and sessions, publication of papers, and by Sections meetings, particularly of those Sections with headquarters at the major centers of automotive manufacturing.

E. P. BLANCHARD,
Chairman.

Research Committee

The year 1929 has been an active one for the Research Committee and its subcommittees, as evidenced by the 27 Committee meetings held during the year. Fuels and riding-qualities have taken the forefront; detonation, vapor lock, riding-comfort, and wheel align-

ment being the chief subjects of interest and discussion, while headlighting and highway research have continued to hold their places in the program.

Fuel Research

Improved distribution is admittedly one of the foremost problems of the day, made increasingly urgent by the steady trend from the four-cylinder car to the six, the six to the eight, and on up to sixteen cylinders. Fortunately, the need for knowledge of the relation between fuel characteristics and engine design has been anticipated and data of untold value to engine builders are contained in the reports of the Bureau of Standards fuel-research conducted under the direction of the Cooperative Fuel-Research Steering Committee, a joint committee of the American Petroleum Institute, the National Automobile Chamber of Commerce and the S.A.E.

Previous experimental work on fuel volatility at the Bureau of Standards has shown that most of the gasoline properties needed for computations can be determined from the distillation curve of the American Society for Testing Materials, particularly through the relation of the 10-per cent point on the A.S.T.M. curve. A paper, Volatility Data on Natural Gasoline and Blended Fuels, presented at the 1929 Summer Meeting, extended this equilibrium-air-distillation work to the more-volatile fuels, requiring measurements at temperatures considerably below 0 deg. cent. (32 deg. fahr.). The results showed that the general relations deduced from earlier investigations are equally applicable to natural gasoline, to straight-run aviation fuels, and to natural gasoline motor-fuel blends. The equilibrium volatility research was concluded by a report given at the same time, which applied to engine performance as affected by vaporization in the manifold and included two nomograms for use in estimating the temperature at which an engine will start easily when using any given gasoline.

The vapor-pressure data secured in the course of the fuel research are now being applied and extended to solve the problem of vapor lock. Under the direction of the Fuels-Research Subcommittee, research on vapor lock in airplane fuel-systems as affected by fuel characteristics was undertaken early last year at the Bureau of Standards with funds provided by the Naturaline Company of America. This project has now been taken over by the Cooperative Fuel-Research Steering Committee, and the investigation is being extended to cover the conditions which exist in automobile engines wherein the phenomenon of vapor lock is frequently encountered but does not present so great a hazard as when it occurs in the airplane powerplant. The results of this work to date are reported in a paper, The Properties of Gasolines with Reference to Vapor Lock, prepared by Dr. O. C. Bridgeman for presentation at the 1930 Annual Meeting of the Society.

The acceleration research, which has been conducted at the Bureau for some time and has been reported in papers before the Society, has during the last year been extended to various types of engine to make the results generally applicable and to determine the effect of engine-design factors that have an influence on acceleration. For this purpose a portable model spark-recording accelerometer, designed at the Bureau and described and exhibited at the 1929 Summer Meeting, has been set up in various automobile manufacturers' laboratories, making possible an identical series of tests on a group of representative automobile engines. The results of these tests are reported by D. B. Brooks and C. S. Bruce in a paper entitled, Effect of Design on Engine Acceleration, to be presented at the 1930 Annual Meeting.

Last but not least among the fuel projects is the investigation being carried on by the Subcommittee on Methods of Measuring Detonation, this Subcommittee being in turn responsible to the Cooperative Fuel-Research Steering Committee. The first phase of this research is nearing completion; that is, the development of a suitable engine for use as a standard instrument in determining the knock rating of fuels. Ten of these experimental engines are now in operation in the laboratories of the members of the Subcommittee, and work during the last few months has resulted in the development of equipment and accessories to complete the set-up preparatory to carrying out a series of tests using the representative knock-testing methods to determine the suitability of the engine for use with any of the methods now in common practice, and to ascertain the effect of engine variables on knock rating.

For the first time in the history of detonation research, several laboratories are working with identical equipment and the same fuels, and are using the same technique. Furthermore, in response to an expression of interest and a suggestion of cooperation from a group working along similar lines in Great Britain, the Steering Committee extended an invitation to the British group to join our Subcommittee in carrying out the proposed tests. Their acceptance has been received and arrangements are under way to supply the new members of the Committee with identical equipment and test fuels. This last step makes the project an international one and paves the way for the second phase of the program, which will involve determining the relative merits of the various methods of measuring knock and, if possible, establish some method or methods as standard procedure that will be universally acceptable.

Headlighting

During the first half of the year the headlight research was continued at the Bureau of Standards. A progress report on this work was presented at the 1929 Summer Meeting at Saranac Inn by H. H. Allen, and the latest development of the photometer for studying and recording glare conditions was exhibited. Following the Summer Meeting, the Headlight Research Subcommittee appointed a special committee to formulate plans for coordinating the individual research studies made by members of the Headlight Research Committee for their own companies, and for continuing the work at a later date.

Highways

The Highways Research Subcommittee is continuing to represent the S.A.E. on the Cooperative Committee on Motor-Truck Impact Tests, under whose auspices the Bureau of Public Roads has been conducting truck impact tests. As previously reported, the Bureau of Standards is cooperating in the study of instrumentation problems. The calibration of instruments used in former tests and the fabrication of new instruments for use in the work have been completed. The data heretofore obtained are now in process of being analyzed and checked.

Riding-Qualities

Commendable progress has been made in riding-qualities research during the year in carrying out the program proposed by Dr. F. A. Moss, head of the Department of Psychology, George Washington University, City of Washington, and approved by the Research Committee a year ago. The Ways and Means Committee appointed by the Council at the last Annual Meeting lost no time in securing the necessary funds for the preliminary work, and the tests for measuring riding-comfort have gone ahead rapidly.

A progress report was presented by Dr. Moss at the last Summer Meeting, and appeared in the September issue of the S.A.E. JOURNAL; and a second report has been prepared for presentation at the 1930 Annual Meeting. Dr. Moss has devised a whole series of tests for measuring body changes brought about through both muscle and nerve fatigue, and, following preliminary riding experiments, has been able to select a few of these tests which are easily applied and give consistent results in measuring elusive types of fatigue, such as are acquired in automobile riding. The development of recording instruments incorporating a counting or integrating arrangement,

thus eliminating tedious working-up of records, is an important part of this work.

It will be remembered that, in coordination with this program, Purdue University has accepted the task of recording the vibrations of automobile bodies and securing the subjective reactions, orally expressed, of a large group of students.

Wheel Alignment

The Research Committee has continued its work of collecting manufacturers' specifications on toe-in, caster angle, king-pin inclination and camber. It is interesting to note that the latest review of alignment conditions shows an improvement in the meeting of paper specifications, according to measurements made of cars at the time of purchase. The checking of the cars against paper specifications at that time and again after every 5000 miles of service has been conducted at the General Motors Proving Grounds under the direction of O. T. Kreusser.

Although the work has not progressed sufficiently for final conclusions to be drawn, the tests have shown that a large proportion of the cars do not check with the manufacturers' specifications at the time of purchase, and indicate that they do not hold their original settings for any considerable time when driven on the road. Methods of measuring tire wear have also been given considerable attention, effort being made to secure a sufficiently accurate measuring device.

Mechanical Springs

The Special Research Committee on Mechanical Springs, of the American Society of Mechanical Engineers, with which this Society is cooperating, submitted a fifth Progress Report at the Annual Meeting of the A.S.M.E. Fundamental studies of the elastic behavior of spring materials have been continued at Union College under the direction of M. F. Sayre, in an effort to lay a theoretical basis for the whole problem of spring design. The Special Committee also sponsored a paper entitled, The Radially Tapered Disc Spring, by W. A. Brecht and A. M. Wahl, presented at the A.S.M.E. Annual Meeting.

Research Department

In addition to the executive correspondence carried on in conjunction with the Research Committee activities, the Research Department of the Society has, through its technical information service, written 1600 letters answering individual requests for information and taken care of hundreds of telephone inquiries and of visitors to the Society's library during the year. The answers to these queries require anything from a simple statement of fact or formula to the preparation of comprehensive bibliographies.

To faciltate this service, about 195 separate issues of technical magazines other than the S.A.E. JOURNAL are perused each month and articles of interest indexed for the card catalogue that serves as a cumulative index to THE JOURNAL, TRANSACTIONS, and a list of other important technical publications. From this material the best articles are selected and abstracted each month for the Notes and Reviews columns of THE JOURNAL. Books of technical interest are also reviewed and added to our library.

Contact has been maintained with the research work carried on at universities, and articles on related and other research topics have appeared each month in the Automotive Research Section of THE JOURNAL.

H. L. HORNING,
Chairman.

Sections Committee

The matter of including Section dues with the Society dues as one charge of $20, which has been under consideration for some years, will probably again be brought up at the Annual Meeting.

Section Finance

By direction of the Council a new budget-form has been printed for use by the Sections, copies of the form having been sent to the Sections with the request that budget expense figures for the year 1929-1930 be entered thereon.

Also, a new resolution dealing with Section entertainment expense was passed by the Council and transmitted to the Sections with the request for further information as to their policy and practice as to entertainment.

Paid Section-membership during the last year showed a normal increase. The number of paid Section members for the last fiscal year was 4301, while for the preceding fiscal year the number was 3642. The table herewith shows the details of Section membership and finances for the fiscal period ended Sept. 30, 1929.

Canada and Northwest Sections Recognized

At the meeting of the Council held on Nov. 26, reports on activities of the Canadian and the Northwest Sections during the last year were submitted, with recommendation for official recognition of these two organizations as regular Sections of the Society, in view of their activities during their probationary period having been adequately successful. Definite action to recognize them was taken by the Council. Accordingly, the Canadian and the Northwest Sections will be represented this year on the Sections and the Nominating Committees of the Society.

New Sections Organized

Since the last Sections Committee report, three new probationary Sections have been organized; namely, the Wichita Aeronautic Section, Wichita, Kan.; the St. Louis Section, St. Louis;

SECTION MEMBERSHIP AND FINANCES, OCT. 1, 1928, TO SEPT. 30, 1929

Section	Section Membership Sept. 30, 1929	Section Dues	Income Appropriation from Society Treasury	Total Section Expense	Expense per Member	Section Papers Published in S.A.E. Journal
Buffalo	143	$682.50	$520.43	$1,354.00	$9.47	2
Canadian	74	309.85	114.83	82.02	1.11	0
Chicago	382	1,827.50	.....	2,901.87	7.60	1
Cleveland	322	1,552.50	276.21	3,784.20	11.75	3
Dayton	94	467.50	195.00	848.66	9.03	1
Detroit	1,158	5,578.50	.....	6,856.92	5.92	4
Indiana	144	700.00	137.37	1,050.36	7.29	2
Metropolitan	979	4,735.00	.....	10,444.75	10.67	12
Milwaukee	139	667.50	219.94	742.12	5.34	3
New England	187	885.00	.....	702.77	3.76	4
Northern Calif.	118	372.50	300.00	350.76	2.97	0
Northwest	84	372.50	200.00	843.34	10.04	1
Pennsylvania	271	1,363.50	.....	2,595.94	9.58	1
Southern Calif.	126	572.50	.....	458.04	3.64	2
Washington	80	367.50	.....	362.59	4.53	0
Total	4,301	$20,454.35	$1,963.78	$33,378.34	av. $7.76	36

and the Pittsburgh Section, Pittsburgh. The initial meetings of these three Sections were held on the following dates:

Wichita, Sept. 20; St. Louis, Sept. 23; Pittsburgh, Oct. 24. The success of the inaugural and subsequent meetings has been very gratifying.

Proposed New Sections

As the Northwest Section has held meetings in both Portland, Ore., and Seattle, Wash., mainly with different groups in attendance at each city, the question of splitting this body into two Sections is under consideration. A group of temporary officers representing Portland members made formal application at the December meeting of the Northwest Section for permission to separate from that body and organize their own Section.

A conference has been held with representative members residing in and near Minneapolis with reference to re-establishing, as the Twin-City Section, the Section formerly active with headquarters at Minneapolis, the revived Section to include in its territory St. Paul and vicinity. A temporary set of officers has been chosen to carry on the preliminary work.

A request has been received from members located in Syracuse and adjacent territory that a Section be started there. Work is under way to ascertain the number of interested members and prospective members before taking definite action looking toward organization conferences.

Professional Activities in Sections

The Sections have in many instances built their meetings around subjects connected with the various officially recognized Professional Activities of the Society. This is particularly noticeable in the case of aircraft and aircraft engines, as reflected by the large number of aeronautic meetings held throughout the Country as regular Section meetings and, in the case of the larger Sections, as Aeronautic Division meetings. It is anticipated that the professional activity set-up will be of considerable value to the Sections in making up their programs and conducting meetings.

VINCENT G. APPLE,
Chairman.

Standards Committee

Since the beginning of the 1929 administrative year immediately following the Annual Meeting last January, the activity of the Standards Committee of the Society has compared favorably with that of previous years. The Committee consisted in 1929 of 20 Divisions and about 75 Subdivisions that were continued from 1928 or appointed during 1929. The Special Committees on Standardization Policy, Methods of Expressing Limits and Tolerances, and on Patents were continued, but it was not necessary for them to hold any meetings during 1929. Although a large amount of the Committee's work was done by correspondence, 17 Subdivision and 19 Standards Committee Division meetings were held.

Progressive changes in the automotive industry have clearly indicated the desirability of confining standardization activities to more fundamental subjects, and accordingly the tendency among the divisions has been to drop unfinished subjects or to cancel existing specifications relating to minor or highly specialized details. Interest in the standardization of small tools and in production-engineering standardization generally increased somewhat during the last year, and work in this connection has been done by the Society's Standards Committee, although the main activity at present is in the Sectional Committee on Small Tools and Machine-Tool Elements, under the sponsorship of the Society, the National Machine Tool Builders Association and the American Society of Mechanical Engineers.

Another phase of standardization that has been evident is that relating to State regulatory codes governing safety and comfort features of public-carrier motor-vehicle construction and the operation of motor-vehicles, with the purpose of eventually having such regulations uniform within the several States of the Union.

Division Reports

During the year, Divisions of the Standards Committee recommended for adoption 42 new specifications, the revision of 27 existing specifications, and the cancellation of 14 specifications in the S.A.E. HANDBOOK. Of these, four were production-engineering standards that were either new specifications or revisions that have been published separately. Eight reports of Sectional Committees for which the Society is a sponsor have also been submitted to the Standards Committee. Ten Divisions submitted reports at the Summer Meeting last June, and 12 Divisions have approved recommendations for consideration at the Standards Committee meeting this month (January). At the close of the 1929 administrative year about 40 unfinished subjects were in progress in several Divisions of the Standards Committee, aside from work in progress in Sectional Committees.

S.A.E. Handbook

The 1929 edition of the S.A.E. HANDBOOK, issued early last March, included all S.A.E. Specifications current at the close of the Annual Meeting last January. The semi-annual Supplement to the HANDBOOK, issued in August, contained the new and revised specifications approved at the Summer Meeting at Saranac Inn, N. Y., and a list of the specifications that were cancelled at that meeting. Approximately 900 companies are named in the list of Manufacturers of Products Conforming to S.A.E. Specifications printed in the HANDBOOK; it is expected that this number will be materially increased. The value of this listing to members and others in the industry has been sufficiently established to make it a permanent section of the HANDBOOK.

Sectional Committees

At the close of the 1929 administrative year, the Society is a sponsor for 10 general Sectional Committees and is represented on 17 others that were organized and are working under the procedure of the American Standards Association. A number of the Sectional Committees for which the Society is sponsor are working on several reports for which Technical Committees were organized under the Sectional Committees.

American Standards Association

The Society is represented on the Standards Council of the American Standards Association, with the Chairman of the S.A.E. Standards Committee as alternate. It is also represented on the Board of Directors of the A.S.A.

International Standardization

The only definite result of direct effort made during the year toward international standardization is the report of the Sectional Committee on Ball Bearings on the standardization of single-row annular ball-bearings of the light, medium and heavy series. This has been approved by the S.A.E. Ball and Roller-Bearings Division. This standard was based on the S.A.E. Standard published in the HANDBOOK for many years but was extended to include larger sizes than are commonly used in automotive work. A few modifications in the existing bearings dimensions were made by both American and foreign manufacturers to bring the entire series of ball-bearing dimensions and their tolerance into general agreement.

Interest is rapidly growing in the leading industrial nations of Europe in organized international standardization. The Internationl Standards Association was organized some years ago by the national standardizing bodies with the exception of those in Great Britain, Canada, Australia and the United States. The American Standards Association has recently become definitely affiliated with the I.S.A., however, and will serve as a channel for exchange internationally of information on standardization.

General Interests

During the year the Society has maintained its representation on about

40 Committees of other National organizations, Governmental departments and bureaus and similar groups that are dealing with subjects involving standards. Although much of this work is of greater importance to the industries in general, a great deal of it when completed will be of value to the automotive industry.

A. J. SCAIFE
Chairman

Transportation Committee

The Transportation Committee of the Society, formerly the Operation and Maintenance Committee, has been active during the year. Meetings of the general Committee were held on Jan. 14, Feb. 4, June 22 and Oct. 2. A number of meetings were also held by the several Subcommittees appointed at the beginning of the administrative year as follows:

(1) Subcommittee on Uniform Cost-Record Forms
(2) Subcommittee on Operation
(3) Subcommittee on Maintenance
(4) Subcommittee on Meetings

The Subcommittee on Training of Mechanics and the Subcommittee on Manpower Requirements in Motor-Vehicle Operation were continued from the preceding year.

The Subcommittee on Operation, of which A. S. McArthur is Chairman, scheduled the five following topics for the preparation of reports:

(*a*) Suitability of Equipment—W. J. Duffy
(*b*) Proper Speeds (Maximum; Rates of Acceleration and Deceleration; Over-All Speed)—E. D. Merrill
(*c*) Standardization of Body Builders' Dimensions — S. B. Shaw
(*d*) Ways and Means of Operating Scattered Fleets — E. W. Templin
(*e*) Personnel Training—Eugene Power

Questionnaires for information or outlines of reports have been circulated on most of these subjects.

The Subcommittee on Maintenance, of which J. F. Winchester is Chairman, assigned the following subjects:

(*a*) Preventive Maintenance in Line with the Elimination of Mechanical Road-Delays —E. C. Wood
(*b*) Self-Maintenance as Compared with Service-Station Maintenance—H. V. Middleworth
(*c*) Uniform Method of Cost Comparison — J. F. Winchester
(*d*) Depreciation of Motor-Vehicle Equipment — Eugene Power
(*e*) Crankcase-Oil Reclaiming—E. S. Pardoe

The outline of the report on Crankcase-Oil Reclaiming has been circulated among the members of the Transportation Committee, and the work of the other members of the Subcommittee is in progress.

The Subcommittee on Maintenance took over the work of the previous year's Subcommittee on Uniform Method of Cost Comparison and numerous data have been collected, and contact has been established with a Committee of the American Petroleum Institute which is studying the same subject in connection with tank-truck operation. The Subcommittee's project is limited at present to methods of cost comparison for motorcoach and motortruck operation. The Subcommittee's project on Chassis Record-Forms has progressed to a tentative recommendation that has been circulated among the members of the Transportation Committee. It is the intention, when this report is completed, to submit it to the Standards Committee and the Society through the Motorcoach or the Motor-Truck Division of the Standards Committee for adoption as S.A.E. Recommended Practice.

The National Transportation Meeting

The Subcommittee on Meetings, under the Chairmanship of F. K. Glynn, did considerable work on a program for a National S.A.E. Transportation Meeting in conjunction with the National Automobile Chamber of Commerce last June at the time of the Military Transportation Pageant and Exposition at Camp Holabird, Md., but circumstances developed that made it desirable to postpone the S.A.E. Transportation Meeting until autumn.

Under the plans formulated by the Subcommittee on Meetings and the Transportation Committee, the 1929 National Transportation Meeting of the Society was held in Toronto, Canada, in November. The meeting extended over four days of morning and afternoon sessions at which many interesting and valuable papers were presented on factors governing the design and purchase of motor-vehicles, fleet operation and maintenance, and problems connected with garage design and equipment. The sessions of the second day were held jointly with the Motor Transport Division of the American Railway Association, to discuss problems of mutual interest. The success of these sessions indicated clearly the closer cooperative relations between the rail transportation groups and the motor-vehicle operators. A well-attended Transportation Dinner was arranged by the Canadian Section as host in cooperation with the Transportation Committee's development of the general meeting-program.

Cooperating on Motorcoach Code

The Transportation Committee has participated during the year in the formulation of the Uniform Motorbus Specifications Code, the publication and promulgation of which have been taken over by the Motor Vehicle Conference Committee since the time of the general conference on the Code in the City of Washington last June. The Transportation Committee is cooperating with the Motorcoach Division of the Standards Committee on this project, but has not yet formally acted on it.

The Operation and Maintenance Department of the S.A.E. JOURNAL has been continued as Transportation Engineering, 17 Transportation articles having been published in this department in the 12 issues for 1929, in addition to 25 technical papers published in THE JOURNAL during the year relating primarily to transportation engineering, and 20 other papers that have direct bearing on transportation engineering.

On the whole, the Transportation Committee has made material progress in the interest of the transportation-engineering membership of the Society, and, with the continuation of the Committee as the Transportation and Maintenance Committee, under the new plan of classifying the activities of the Society that was recently adopted, the growth in the number of transportation-engineering members should continue.

It is necessary that all the members, particularly those who have accepted appointment on the Committee, give the work their prompt and effective attention in order to make progress. Unfulfilled obligations will only retard the development of our transportation interests that are as important to the Society and the industry at large as are design and production engineering. With the interest and cooperation of the members stimulating the work of the Transportation Committee, greater results can be accomplished during the coming years.

F. C. HORNER,
Chairman

Treasurer's Report

The 1928-1929 fiscal year of the Society closed with a very good financial outlook, as the following Balance Sheet and Income Expense Statement show.

In brief, the total income of the Society has for the first time passed the $400,000 mark, with expenses rapidly approaching that figure. The income for the year increased $38,383.88 over that of the previous year, while expenses increased only $24,276.82. This left an unexpended income at the close of the year of $18,706.70, or $14,107.06 more than that of the previous year;

allowing the Society to increase its investments in securities by $22,246.25.

The increase in income is primarily due to the increase in S.A.E. JOURNAL advertising rates advocated by the Finance Committee and approved by the Council.

During the last few months the Finance Committee and the Council carefully reviewed the investment policy of the Society that has been in force for several years. It was the unanimous opinion that that policy is best.

This being my 12th Annual, and my last, report as your Treasurer, I desire to express my great appreciation of the honor and trust you have bestowed upon me, and to assure you that it has always been a great delight to have in some slight measure contributed toward the phenomenal success of our Society, which has been so skillfully and unselfishly managed by Coker Clarkson, whom we all love and esteem, and who has built up about him an organization that has so faithfully and competently carried on the work with him.

It is my belief that the Society of Automotive Engineers has been built up by the unselfish efforts and cooperation of its members. Each member has taken out of this Society a vast fund of knowledge, a thousandfold more than he has contributed. I feel that without the Society of Automotive Engineers the automotive industry would never have attained the position it now holds. It was this organization that coordinated the personnel and the scientific minds of the pioneers and followers of this great industry who said, "We will, as members, build the greatest industry in the world"—and you have done so.

C. B. WHITTELSEY,
Treasurer.

COMPARATIVE BALANCE SHEET AS OF SEPT. 30, 1929, AND SEPT. 30, 1928

(In agreement with Haskins & Sells' audit of the same date)

Assets	1929	1928	*Increase*	*Decrease*
Cash	$13,523.59	$13,765.55	.....	$241.96
Accounts Receivable	27,603.10	16,652.17	$10,950.93	.....
Securities	214,577.00	192,330.75	22,246.25	.....
Accrued Interest on Securities	3,480.41	3,178.33	302.08	.....
Inventories	1,038.95	1,106.30	.....	67.35
Furniture and Fixtures	1,000.00	2,248.58	.....	1,248.58
Items Paid in Advance, Charges Deferred	5,332.88	7,427.74	.....	2,094.86
TOTAL ASSETS	$266,555.93	$236,709.42	$29,846.51	
Liabilities and Reserves				
Accounts Payable	17,176.15	4,010.35	13,165.80	.....
Dues and Miscellaneous Items Received in Advance	17,691.49	17,719.78	.....	28.29
Reserves Set Aside for Anticipated Expense	1,923.43	3,921.13	.....	1,254.04
General Reserve	211,058.16	206,458.52	4,599.64	.....
Net Unexpended Income	18,706.70	4,599.64	13,363.40	.....
TOTAL LIABILITIES AND RESERVES	$266,555.93	$236,709.42	$29,846.51	

INCOME AND EXPENSE AND BUDGET COMPARISON—12 MONTHS ENDED SEPT. 30, 1929

(In agreement with Haskins & Sells' audit of the same date)

	Oct. 1 to Sept. 30		Budget
Income	1928-1929	1927-1928	1928-1929
Dues and Subscriptions	$96,148.75	$88,542.50	$91,000.00
Initiation Fees	18,975.00	17,640.00	17,500.00
Affiliated Appropriations	7,500.00	7,500.00	7,500.00
Interest and Discount	10,647.97	9,843.17	11,000.00
Advertising Sales, S.A.E. JOURNAL	244,869.50	214,466.00	240,000.00
Advertising Sales, S.A.E. HANDBOOK	12,000.00	11,000.00	12,000.00
Miscellaneous Sales	14,970.61	16,617.28	16,000.00
Profit from Sale of Securities	26.25	1,145.25	.....
TOTAL INCOME	$405,138.08	$366,754.20	$395,000.00
Expense			
Research	18,264.56	16,787.40	18,000.00
Standards	22,990.79	24,561.74	24,600.00
Publications	98,609.40	93,583.13	98,600.00
Meetings	35,807.79	27,683.15	27,200.00
Sections	11,547.48	13,809.65	15,200.00
Professional Activities[1]	584.67	481.48	1,000.00
Cost of Membership Increase	12,674.92	12,095.78	12,950.00
Cost of Advertising Sales, S.A.E. JOURNAL	74,804.21	64,491.90	69,500.00
Cost of Advertising Sales, S.A.E. HANDBOOK	2,699.47	2,222.84	2,500.00
Miscellaneous Sales	7,215.46	7,094.70	7,000.00
General Expense[2]	101,232.63	99,342.79	100,950.00
TOTAL EXPENSE	$386,431.38	$362,154.56	$377,500.00
Net Unexpended Income	$18,706.70	$4,599.64	$17,500.00

[1] Professional Activities include S.A.E. Transportation Committee and S.A.E. Production Committee.
[2] General Expense includes Employment Service, Administration of Medal Awards and Standards Show Exhibits.

Meetings Committee

Several interesting and important items in connection with the National-meetings work of the last year deserve special consideration. For the first time, the Society has held four National Aeronautic Meetings within a period of one administrative year; for the first time, the Society has held two National Motorboat Meetings in a similar period. The 1929 Transportation Meeting was a four-day gathering; the 1930 Annual Meeting, a five-day affair; each of these two meetings being longer by one day than the longest predecessor of either.

A study of the topics treated at the meetings covered by this report shows that, in addition to specialized technical papers, an important feature of the programs was the discussion of many of the broad phases of the industry and the general engineering aspects of it. This policy has also been followed with marked success by some of the local Sections.

Eleven Meetings of National Scope

Eleven National Meetings were held during the 1929 administrative year, from the close of the 1929 Annual Meeting to the close of the 1930 Annual Meeting. The table included with this report lists these meetings, giving data relative to the locations, dates, number of sessions and number of papers presented.

An examination of the respective locations of the meetings reveals two interesting facts: first, the holding of three meetings at Detroit, two at Cleveland and two in New York City indicates a suitable concentration of activities at the chief centers of automotive interest; second, the holding of one meeting each in such widely separated places as Saranac Inn, Toronto, Los Angeles and Miami is significant in that it shows both the geographical expansion of the Society and the intention on the part of those arranging programs to hold meetings at places convenient to many members who would not otherwise have an opportunity to attend a National meeting of the Society.

Section Cooperation Marked

Section cooperation in National meetings has been very marked in the last year. The Detroit Section Aeronautic Division took a very active part in arranging for the Aeronautic Meeting at Detroit in April; the Detroit Section rendered valuable assistance in connection with the Motorboat Conference held there in August, and the Detroit Section Body Division has sponsored a dinner and session at the 1930 Annual Meeting. A dinner was held in connection with the Aeronautic Meeting at Cleveland in August and another at the Production Meeting in October, and on both occasions the Cleveland Section acted as host. The Canadian Section assisted in staging the Transportation Meeting, held at Toronto in November, and acted as host at the Transportation Dinner. Much of the success of the Aeronautic Meeting at Los Angeles in November was due to its being sponsored by the Southern California Section Aeronautic Division, and the Metropolitan Section cooperated splendidly as regards both the preliminary arrangements and the actual running of the Motorboat Meeting in New York City in January, 1930. These typical examples of Section cooperation indicate the close working relationship that exists throughout the Society.

NATIONAL MEETINGS HELD IN 1929 ADMINISTRATIVE YEAR

Meeting	*Location*	*Date*	*No. of Sessions*	*No. of Papers*
Aeronautic	Detroit	April 9 and 10	3	6
Summer	Saranac Inn	June 25 to 28	9	31
Aeronautic	Cleveland	Aug. 26 to 28	5	15
Motorboat	Detroit	Aug. 31	1	3
Production	Cleveland	Oct. 2 to 4	3	3
Transportation	Toronto	Nov. 12 to 15	9	24
Aeronautic	Los Angeles	Nov. 12 and 13	2	6
Annual Dinner	New York City	Jan. 9, 1930	1	1
Aeronautic	Miami	Jan. 14, 1930	1	3
Motorboat	New York City	Jan. 22 and 23, 1930	2	7
Annual	Detroit	Jan. 20 to 24, 1930	16	28

Cooperation with Other Organizations

Eight of the National meetings were held in cooperation with other organizations. The Detroit Aeronautic Meeting in April was held in cooperation with the Aeronautical Chamber of Commerce of America and the Detroit Board of Commerce Aeronautic Committee; the Cleveland Aeronautic Meeting in August was sponsored jointly by the Aeronautical Chamber of Commerce of America and the Society, as was also the Los Angeles Aeronautic Meeting in November; and the Miami Aeronautic Meeting in January, 1930, was in conjunction with the All-American Air Races. Both of the Motorboat Meetings were joint meetings with the National Association of Engine and Boat Manufacturers, and the Production Meeting was held cooperatively with the National Machine Tool Congress and the American Society of Mechanical Engineers. One of the four days of the Transportation Meeting was devoted to two joint sessions with the Motor Transport Division of the American Railway Association.

As the report of the 1928 Meetings Committee, published in the February, 1929, issue of the S.A.E. JOURNAL, covered the calendar year 1928 and not the administrative year ending at the close of the 1929 Annual Meeting, the 1929 Annual Dinner and Annual Meeting were not mentioned therein. The former, held at the Waldorf-Astoria Hotel, New York City, on Jan. 10, was one of the most enjoyable and successful banquets ever staged by the Society. Will Rogers was the speaker. The Annual Meeting, held in Detroit, Jan. 15 to 18, inclusive, was a four-day event comprising 12 technical sessions at which 33 papers were presented.

The programs for the various meetings during the last administrative year were arranged by the program committees of the respective activities or by special committees appointed for a particular meeting. Great credit is due these committees. The very effective work of George L. McCain, Chairman, and the other members of the so-called Motor-Vehicle Committee is deserving of special commendation.

Society members in general and committee workers in particular appreciate the fact that the 1929 year of progress and expansion in National meetings could not have been recorded without the loyal and efficient work of the members of our Headquarters staff. Only through them has it been possible to establish new records of accomplishment. In no small measure are they responsible for the position of leadership that the Society has so definitely maintained in the important branches of automotive engineering activity.

JOHN A. C. WARNER,
Chairman.

Inter-American Aviation Problems

Representative Group at Miami Aeronautic Meeting Hears Addresses by Young, Eaton and Stout on Tropical Airline Development

THE FIRST of a series of Aeronautic Meetings to be held in the South was held the evening of Jan. 14 at the Columbus Hotel, Miami, Fla., in conjunction with the All-American Air Races conducted at the Miami Municipal Airport on Jan. 13, 14 and 15, which attracted a large number of pilots and aeronautic men from all parts of the Country. While the attendance was not large, a very representative group was present to hear the three papers which were presented.

The first, by Clarence M. Young, on Problems of International Flying, was an excellent treatise on the questions involved in aerial contact with foreign countries in international passenger traffic.

Declaring that American organizations now operate over 15,000 miles of airways in contiguous countries, maintaining approximately 80,000 or 90,000 miles of scheduled service each week, Major Young called attention to the fact that part of this flying was done in Canada, Mexico, Central and South America, Cuba, the West Indies and the Bahamas, transporting passengers, mail and merchandise. It is his opinion that eventually, perhaps within a decade, we shall have transoceanic service that is reliable in character and certain in operation.

Problems of International Flying

The more serious problems involved in international flying, according to Major Young, fall into three distinct groups; first, the type of equipment to be employed, including not only aircraft but ground facilities, such as radio and communication services, weather-reporting systems, intermediate landing points, navigation equipment and aids, and operating personnel; second, international agreements, including customs, entry and clearance, airworthiness phases, the definite separation of military and civil operation, all of which make necessary a general recognition of international controllability comparable with that of shipping, but which partakes of certain elements not akin thereto; and third, the economics involved, that is, the operating expense, the essential offset in the matter of transportation rates, and the business potentialities as a result thereof.

Discussing aircraft and equipment, Major Young asserted that any type of aircraft employed must provide a payload capacity consistent with the operating cost. In transoceanic services, it must also be capable of sustained flight of unusual duration, and for the time being at least transoceanic services will of necessity be limited to dirigibles. In this connection, he called attention to the intermediate landing and service facilities which will be required and are now being experimented with in the form of "floating islands" equipped with radio, hangars, machine-shops and other necessary devices.

On the subject of international cooperation, Major Young called attention to the fact that, whereas aircraft require certificates of airworthiness and pilots must have certificates of competency, different countries have varying requirements; and this has to some extent presented complications which, however, are gradually being adjusted. A preliminary Pan-American convention has been organized as a result of the Pan-American conferences in 1926 to deal with some of the problems arising in air communication with South and Central American countries. Urging further developments along these lines, the speaker said:

> Air transportation offers a medium of movement unequaled in speed or directness of route by any existing or known transport system; it is proving itself to be amenable to the age-old laws of economics; design and development of aircraft, ground facilities, instruments, equipment and so forth are rapidly removing any peculiar hazards, thus extending the sphere of usefulness and increasing safety and reliability; and business and commerce are definitely taking advantage of the improved transportation facility which is being made available. The cycle of progress will surely be applied in the case of air transport as it has been in the introduction and development of other forms of transportation.
>
> I have referred to only a few things which present themselves as difficulties in world-wide international air transportation. There are others; perhaps many of them. However, the same has been true in any other form of transportation and in most new industrial undertakings. They have been overcome. They will be overcome in air transportation, whether interstate or international, and in due course aircraft of the United States will be plying the air lanes of the world, not only in the interests of industry and commerce, but of international peace and good-will.

Developing an International System

J. M. Eaton, traffic manager of the Pan-American Airways, presented in his paper problems the solution of which has been necessary before his lines could operate over the vast territory and through the different nations in a way which represents commercial success. The operations of the company are over flat country, mountain regions, inland waters, bays and various parts of the ocean. The original survey trips required weeks of planning before suitable airways, landing-fields, permanent water-landings and weather stations could be completed.

In the beginning, various policies were established such as requiring a proper ratio of load to power, of not carrying passengers on ships not provided with radio, and of having a co-pilot, a pilot radio-operator and a steward as a crew. The study of the comfort of passengers was given every consideration and expressed itself in the development of comfortable chairs, pleasing color effects in keeping with the Latin's fondness for color, and consideration for glare.

In developing the system, arrangements have been made for a complete tie-in of the company's lines with established passenger transportation systems throughout the United States, resulting in the establishing of a system whereby a traveler can buy a ticket in any of the passenger railroad stations in this Country to all points on the Pan-American Airways.

Mr. Eaton further called attention to the fact that because the cost of operating an airline in foreign countries will always be greater than in domestic operations, rates will of necessity be higher in international air traffic.

Variety of Engineering Required

The importance of proper equipment, the vast resourcefulness and preparations necessary for the maintenance of this equipment, and the extension of

supply bases, ticket offices and other passenger facilities, was emphasized and indicated the great variety of engineering that was necessary on the part of the company to obtain satisfactory results along these lines. Dealing as they do with foreign countries whose language, customs and manners are entirely different in most respects from those in the United States, unique methods often had to be employed before operation could be successfully established.

Mr. Eaton pointed out the extensive recourse to all forms of engineering other than aeronautic which had to be taken in the preparation of airports, radio equipment, motor-truck and other means of ground transportation, the construction of buildings and airports, and the establishment of fuel and oil systems. He further outlined the three types of equipment used, namely, the tri-motor Fords and Fokkers and the Sikorsky Amphibian, on the various parts of the route covered by the company, and the reasons underlying the use of the different equipment.

The Pan-American Airways airport at Miami, one of the finest in the Country, has become, not only the jumping-off place for South American countries, but an intermediate stop for private planes on their way south of the equator. It is not difficult to see, after an inspection of this airport and its maintenance equipment, the result of the thorough studies which have been made into all of the subjects before operation was started.

Lighter Amphibians Needed

Discussion which followed the presentation of Mr. Eaton's paper, relative to the need for suitable amphibians for service between North and South America and between the islands served throughout the West Indies, was a fitting introduction to a very interesting talk given by William B. Stout, president of the Stout Air Lines and designer of the Ford tri-motor airplane.

Declaring that conditions for flying from Florida to the Central and South American countries demand an improved amphibian type of plane, Mr. Stout outlined the trend of design which must ultimately come. An amphibian must be developed which will be at least as efficient as our present land-planes. Under present design, land planes are 30 per cent more efficient, he said, than flying-boats and 50 per cent more efficient than amphibians. It is undeniable that at present these latter ships are too heavy, and steps must be taken to reduce this weight. Some means must be found to obtain a structural arrangement that will give more area for the same wing weight and equal strength.

Mr. Stout expressed the opinion that increased hull strength must be accomplished with no more weight than that of land planes. Engines, passengers, struts and wires must eventually be inside, out of the airstream. Speed of 200 m.p.h. must be obtained if economical operation of airlines is to become a fact.

New metals now being developed will revise engine weights and increase engine life to possibly 1000 hr. or more. With such factors as these, real progress should be made in the next two years to the extent that present equipment will be obsolete.

Commercial equipment today is largely a National growth from military equipment and is not the result of research to obtain just what the commercial industry must have for its requirements. According to Mr. Stout, the remarkable thing in aviation is that the airlines have been able to make such a showing as they have made with the available equipment. Development has been hindered by the entry of moneyed interests and the desire to make a financially successful industry, resulting in production ambitions and inventories which for economic reasons prevent proper engineering progress.

Startling Developments Expected

The most startling developments probably will come from some experimenter working in a barn and having no money, thereby being forced to short-cuts and the most direct results.

Aside from airplanes themselves, some infallible navigation apparatus must be devised. At the present time, radio is the most notable, but the airplane range could be improved as much as 50 per cent by the use of fuel-injection engines.

Concluding, Mr. Stout said that the future of aviation is still in the hands of engineers, aeronautical, metallurgical, chemical and all others. The first step toward a development of the commercial business of the airplane companies lies in the development of a small plane for the individual, which the owner can be taught to fly safely in from 4 to 5 hr.

There was considerable discussion of Mr. Stout's remarks by Stedman Hanks, of Stedman Hanks & Co., and by G. A. Page, of the Curtiss Aeroplane & Motor Co. Mr. Eaton, at Mr. Stout's request, discussed the requirements, in the field of amphibians, of such an airline as is operated by his company, and agreed with Mr. Stout's analysis of what must come.

Air Races and S.A.E. Meeting

The All-American Air Races have undoubtedly taken a place as one of the annual aeronautic events of importance, and it is not too much to prophesy that next year, which will be the third annual affair of this kind, the races will attract an even greater number of contestants and aeronautic engineers and executives.

Unfortunately, bad flying weather held up a large number of planes in the northern part of Florida and in surrounding States, so that it was impossible for many of the contestants and others flying to Florida to reach Miami before the third day of the meeting. At one time 14 planes were grounded at Jacksonville by poor visibility and low ceiling.

Present plans call for the holding of the 1931 All-American Air Races on Jan. 14, 15 and 16, and it is anticipated that the S.A.E. Aeronautic Meeting will be held on the evening of Jan. 15, in the form of a joint dinner with the Industrial Board of the Chamber of Commerce in Miami. These plans, however, are only tentative.

February Aeronautic Meeting

Twelve Technical Papers To Be Given at Six Sessions in St. Louis on Feb. 18, 19 and 20

As a compliment to Colonel Lindbergh, and so that those engineers who reside in the West may have opportunity to attend the important technical sessions, the Society has selected St. Louis as a meeting place for the next National Aeronautic Meeting. The sessions are to be held at the Hotel Jefferson Feb. 18, 19 and 20, during the International Aircraft Exposition.

Five sessions and 12 papers devoted to aeronautic engines, fuels, instruments, production and radio will make the meeting of more than usual importance to those interested in air transportation.

Vapor Lock and Radio Facilities

Herbert Hoover, Jr., the son of the President, will discuss radio communication and transport work. Dr. O. C. Bridgeman, of the Bureau of Standards, is scheduled to explain vapor

(*Concluded on p.* 293)

Annual Meeting Largest Ever Held

(*Continued from p.* 145)

inventions and designs for aircraft or parts thereof submitted to the Government. The committee is authorized to buy for the Government any invention or design that seems desirable and useful at a price not to exceed $75,000, whether patented or unpatented. In the first 1½ years approximately 700 inventions were received and reported upon, only three of which received a tentatively favorable preliminary report.

Although a tremendous amount of effort is wasted in invention, there seems to be no way of stopping it, because by the time a man has worked out his idea he is irredeemable and will not believe that it is of no use. The coordination in the case of the Government has been an admirable thing, but it is necessary to have a certain turnover in the inventions personnel of an inventions committee or to have inventions examined as a sideline by a number of persons who are doing other things as well, if the one grain of wheat in the barnyard full of chaff is not to be overlooked.

Difficulties of the Inventor

One of the most important and difficult questions relating to invention was raised by Charles P. Grimes, of the Grimes Brake Service Co., who mentioned the large number of men who conceive ideas but do not know whether they have practical value. The large corporations "do not want to associate with or discuss the ideas with them until they have got some protection." Patent attorneys urge them to take out patents and pay large fees for searches, applications, attorney's services and so forth for patents that may not be worth anything.

Mr. Grimes made an appeal for someone to tell how a way might be found for inventors to have their ideas considered as to merit before going to so much trouble and expense. Something should be done to protect would-be inventors against such exploitation. Again, the Patent Office examiners sometimes return an application with the statement that the invention will not work, whereas the inventor may have a model already working.

Mr. Tibbetts stated that a bill is now before the Congress, which the Manufacturers Association has been advocating for a number of years, to give the Commissioner of Patents more authority over patent attorneys so that he can stop to some extent the practices of unscrupulous attorneys.

The S.A.E. would have a wonderful field before it in saving human suffering by a concerted effort to set up some machinery to function as an advisory board for inventors, suggested Jacob Ehrlich, of the General Motors Corp. Such a board could cooperate with an official organization of reputable patent attorneys and make recommendations to an inventor's attorney in such a way that no suspicion would be entertained to either the profession or the inventors. That would help the situation tremendously, making it easier for the corporations in weeding out the undesirable inventions.

Practice of Patent Office examiners in rejecting claims on the ground of anticipation by prior patents that really do not anticipate, thereby involving more study and work by the patent attorney and loss of time and money by the inventor, was criticized by L. F. Burger, of the International Harvester Co. This situation arises, thought G. A. Schreiber, a consulting engineer of Detroit, because of the constant changing of examiners in the Patent Office. He suggested that the technical societies in this Country could create a "terminal" where all members or their friends could have certain patent matters looked after without cost. M. L. Wolfard, of Hopewell Brothers, said he did not know whether the Society could do anything in the matter but that the situation weighs down heavily on the inventor.

Standards Committee Session

B. M. Smarr Tells How Manufacturers Should Aid Standardization—Division Reports Approved

THE ANNUAL Meeting of the Standards Committee convened at 2:00 p.m. on Monday, Jan. 20, A. J. Scaife, Chairman of the Committee, presiding. After declaring a quorum, the chairman welcomed those present and called attention to the provisions of the Standards Committee Regulations governing the Standards Committee Meeting. He then introduced B. M. Smarr, director of the standards section of the General Motors Corp., who presented an informal discussion of the following topic that had been scheduled for this session.

Responsibility of Individual Manufacturers

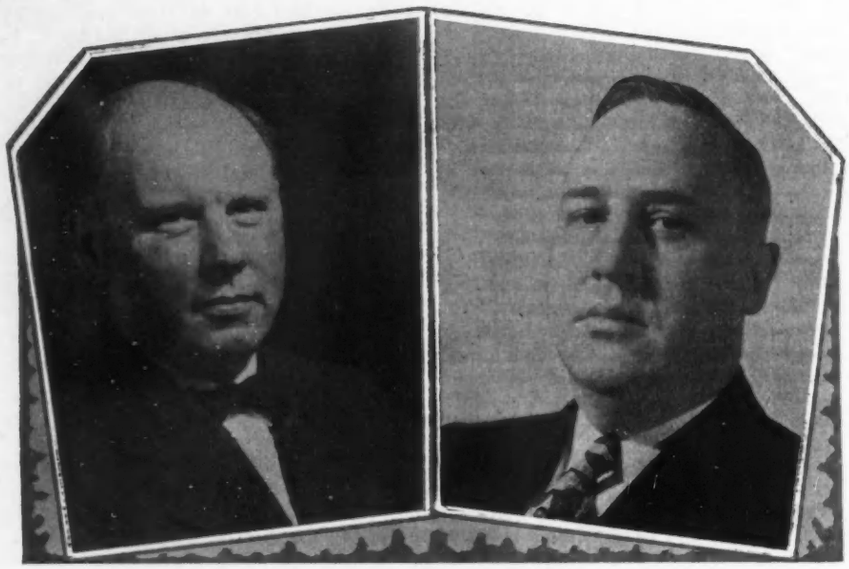
Lack of adequate familiarity with what standards have been adopted by the Society and published in the HANDBOOK seems to be one of the most frequent reasons for the standards not being used by individual manufacturing companies to the extent they should be used, according to Mr. Smarr. He stated that the General Motors Corp. uses S.A.E. Standards wherever and whenever possible, studying the fundamentals of the standards and attempting to use all the principles involved. Where the standards are not complete the corporation is always willing to give of its experience to help make them so. A number of standards, such as the S.A.E. Standard for Woodruff Keys, were cited that apparently have not been fully appreciated by the automotive manufacturers. C. F. Kettering was quoted as having said that "it takes three years to sell a new idea," and Mr. Smarr stated that with standards it seems to take much longer.

The reports on milling-cutters and slotted-head screws that were to be submitted to the Standards Committee during the day were reviewed by the speaker, who urged that they be carefully studied, together with all the other reports to be submitted, so that the greatest good can be derived from them. He urged all automotive manufacturers to thoroughly support the standards of the Society once they have been properly developed and adopted, especially in their dealings with the sellers of products with which the standards are concerned. He mentioned the tendency to disregard the S.A.E. Standards, for tubular rivets, for example, to take advantage possibly of some very slight difference in price, but with such variations from the standard as body-diameter tolerance that would either cause trouble in the shop or restrict the purchaser to one source of supply for probably both rivets and riveting machines.

Certain American Standards Not Practical

The American Standard on Bolt, Nut and Rivet Proportions had been applied in the General Motors plants with con-

siderable saving until certain revisions were made that resulted in more or less trouble in the shop, remarked Mr. Smarr. This condition led to a thorough analysis of the whole situation by the corporation with regard to this standard and the decision to return to the old S.A.E. Standard for sizes of hexagon bolt-heads and nuts. The point in this connection was that too frequently the tendency is to approve standards without sufficiently careful analysis of the engineering and commercial conditions that must govern the practical use of such standards.



STANDARDS-SESSION CHAIRMAN AND SPEAKER

A. J. Scaife, of the White Motor Co., Who Presided; and B. M. Smarr, Director of the Standards Section of the General Motors Corp., Who Discussed the Manufacturers' Responsibility in Supporting Standardization

Another standard approved under the plan of the American Standards Association that proved to be impractical is that for Cylindrical-Hole Tolerances and Gages. The data, he said, are theoretically correct and thoroughly consistent from the mathematical standpoint but experience had proved that the tolerances are wholly impractical for use except in a few special cases. One of the reasons for this is that the maximum life of standard tools used in making a product was not allowed for in the application of this standard. The General Motors Corp., tool-standard subcommittee made a careful study in actual production of the amount by which standard tools would cut oversize, and with the data obtained a standard was developed for a number of classes of fit that can be obtained in using standard tools.

Industry Should Use the Standards

In closing his remarks, Mr. Smarr stated that the manufacturers of parts, tools and equipment cannot be expected to fight the car manufacturers' standardization battles for them; specifications must start with the experience in using the product and be developed from a practical and economical standpoint, so that the final standards will reflect consideration of the whole economic picture of both manufacturer and consumer. As the final cost of the finished product to the consumer is the all-important figure, the judicious establishment of standards must take into consideration all of the factors involved. It should not be expected that a specific saving is always possible on each individual application of a new standard, as cost of the individual items may sometimes be increased, but reduction of over-all cost is the objective that must be kept in mind in setting up and using the standards.

Mr. Smarr's final thought was that all of the industrial interests must make an honest attempt to apply the standards set up by the Society and that, if any of these standards are not found thoroughly practical, the manufacturers' experience and suggestions for correcting them should be sent to the Society, especially if the difficulties encountered have been solved to their own satisfaction.

THE DISCUSSION

CHAIRMAN A. J. SCAIFE:—I appreciate very much the references made by Mr. Smarr to some of the standards and wonder whether, when we find they do not fit our particular needs or we discover discrepancies in them, we lay them aside and go our own way instead of calling the Society's attention to the matter. By doing so the value of the standards is lost or very much lessened. It has been said many times in the Standards Meetings that standards should always follow and never precede general practice. Errors have crept into our standards because of enthusiasm to get ideas adopted before they have been thoroughly tried. There are instances of standards having been in the S.A.E. HANDBOOK for several years without being used and then being recalled because they had not been thoroughly worked out. I do not believe we can overstress the necessity of being careful along this line.

The tables, tolerances, and so on in the standards frequently involve a great amount of detail and it is very easy for errors and discrepancies to creep into them. I urge upon the members, mostly those in plants having their own standards department or having individuals for this work in their engineering department, that they constantly check the S.A.E. Standards and call such errors or discrepancies to the attention of the Standards Committee of the Society.

Action on Division Reports

At the regular meeting of the Standards Committee, reports on 42 subjects were submitted by 13 Divisions of the Standards Committee, all but two of these reports having been printed in full in Section II of the January issue of THE JOURNAL. Three classes of reports were submitted: those for adoption only as S.A.E. Standards, those that were acted on for both S.A.E. Standards and American Standards under the procedure of the American Standards Association, and some that were submitted at this time only for action on them as American Standards.

A few modifications in the reports as submitted were made at the meeting, in some cases as corrections and in other cases revision based on additional information or to make them more consistent in some detail with other existing specifications of the Society. A number of the reports consisted of recommendations to cancel existing standards in the present S.A.E. HANDBOOK that have become obsolete or for which subjects it is felt a standard is of little use because of the nature of the product concerned and its use.

The report on roller chains, cutters and sprockets is the culmination of many years of work that has taken into consideration, so far as possible, principal foreign practice, and it is hoped will enable American chain and cutter manufacturers and users to conform to the standard in the greatest part of their work within the field that the standard is intended to cover. The reports of the Production Division that relate to cutting-tools and gages that are in common use by virtually all manufacturers are indicative of broad efforts that are being made to bring

together the production engineers of various mechanical industries for the establishment of practical standards that should become of great economic value to all of them. The report of the Screw-Threads Division on slotted-head screws should do a great deal to stabilize the manufacture and use of this class of screws, regarding which there have been many differences in practice that are not regarded as necessary. The reports of the Tire and Rim Division should go a long way toward stabilizing tire and rim practice for passenger-cars and commercial vehicles in this Country, especially with regard to their use as original equipment. It is believed that these reports are another progressive step toward the elimination of an unnecessary variety of tire sizes.

A detailed account of the action taken on the reports of the Divisions, with the more important discussion on them from the floor of the meeting, is printed in the Standardization Progress section of this issue of THE JOURNAL, together with an account of the confirming action taken by the Council of the Society and at the General Business Session subsequent to the Standards Committee meeting.

Forty-four members of the Standards Committee and 34 Society members and guests registered their attendance at this Standards Session.

Body Making Here and Abroad

Flexible and Rigid Construction Contrasted—English Three-Point Suspension Reduces Weight

DIFFERENCES between small and large production of all-metal body construction in Europe and the United States were brought out strikingly in papers presented at the Body Conference on Thursday afternoon, at which H. R. Crecelius presided.

One of the highly interesting features of the session was the showing of several reels of motion pictures following the presentation of Dr. George L. Kelley's paper on the construction of rigid one-piece bodies by the Edward G. Budd Mfg. Co. The first of these reels showed the manufacturing process and the others illustrated strikingly the strength of American all-steel bodies in rolling over and over repeatedly downhill.

Opposed Schools of Thought

Two opposed views are held by body engineers, some maintaining that as the chassis is flexible, the mounting of rigid bodies on the chassis is inconsistent, whereas the other school holds that bodies should be made rigid and the chassis frame thereby stiffened.

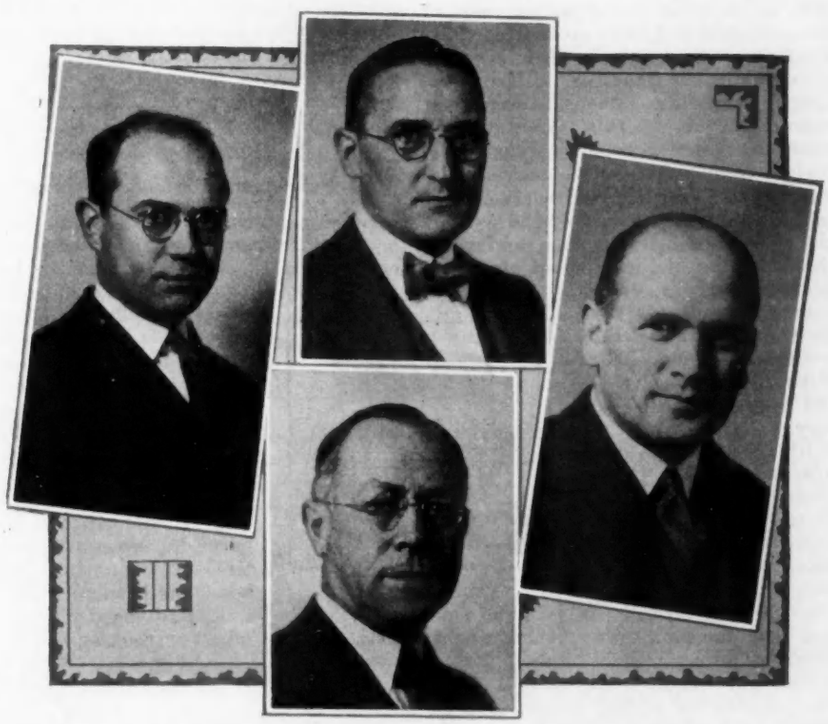
The first paper was presented by Thomas L. Hibbard, representing Hibbard & Darrin, of Paris. He gave an interesting review of European design and body construction. Foreign coach builders have the important advantage over our body builders that custom building constitutes a much larger proportion of the business on the Continent and in England than here, and therefore new designs can be quickly incorporated. European car and body buyers display good taste in their demands for refinement, elegance and color schemes, and this is reflected in the manufacturers' displays at the London and Paris automobile shows and also in special exhibitions at European resorts, such as the Riviera.

Deploring the handicap of lack of talent in body designers both here and abroad, Mr. Hibbard expressed the opinion that not enough serious effort is being placed on the education of designers to qualify them to create new lines, details and interiors. Boys possessing artistic inclinations are much more likely to develop into artistic designers than are those who take a course in designing merely with the intention of entering the purely mechanical side of the business, and some efforts should be made to attract and develop the right kind of talent.

All-Metal Bodies in France

Various European body builders recognize the advantages of all-metal body construction but owing to limited production lack the necessary equipment to go far into pressed-metal work. Voisin, of France, has for some time been building metal bodies which do not follow the general style of appearance or layout but embody many ingenious and meritorious solutions of problems. This builder is one of the great exponents of light-weight bodies, recognizing the important bearing that body and car weight have on acceleration. The influence of the Weymann flexible-body construction has been most beneficial in Europe, according to Mr. Hibbard, but Weymann has been forced by public preference to substitute metal for fabric covering on his articulated wood frame.

Another interesting construction has been originated in France by the Marbeuf Company. This is very simply worked out, consisting merely in shaped metal panels with the edges turned



BODY-CONFERENCE CHAIRMAN AND SPEAKERS

(Top) H. R. Crecelius, of the Lincoln Division of the Ford Motor Co., Presided; (Left) T. L. Hibbard, of Hibbard & Darrin, Described European All-Metal Body Construction; (Right) E. C. Gordon England, of the Gordon England Co., Explained Flexible Body Construction and Suspension; and (Bottom) Dr. George L. Kelley, of the Edward G. Budd Mfg. Co., Described and Showed Motion Pictures of American All-Steel Body Construction

over to form flanges which are bolted together with a special rubber strip between them. The doors are very light and have about the same degree of flexibility as the fabric-covered Weymann doors.

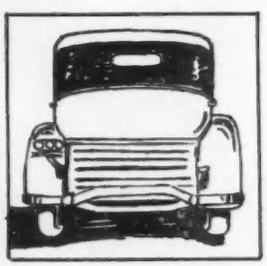
The firm of Hibbard & Darrin in Paris has also been working for some time on all-metal bodies and has two types of construction well developed and adapted to rather small production. In one type the doors are made with a cast aluminum-alloy frame covered with sheet aluminum, and the cowl and rear panels are built up in the same way. In the other type the entire exterior of the door is cast in one piece and the body panels are built up of castings.

Superiority to Composite Bodies

This latter method, while preferable, requires exceptional foundry facilities, difficult pattern work and alloys that are considerably lighter than the ordinary casting alloys. A great proportion of the firm's bodies are collapsible and are designed around panel construction stopping at the belt. The firm's metal bodies are lighter, stronger, more readily repairable and less sensitive to climatic variation than composite wood bodies, according to Mr. Hibbard.

The speaker deeply regretted that the Lancia works had not been able to do more development on the body problem, as its first metal bodies were of pressed steel and built so that no chassis frame was required. This is a line of development that Mr. Hibbard believes merits the serious attention of manufacturers in this Country, and which he believes would be easy to incorporate in a front-drive car.

Another form of construction that merits attention because of the weight-saving possibilities is one in which the framing is comprised for the greater part of drawn tubing, such as is used in aircraft construction.



In conclusion, Mr. Hibbard expressed a belief that, with the factory and laboratory facilities available to manufacturers in the United States, more attention should be given to developing new methods of construction and that body engineers should be given greater latitude in trying to perfect body development by attacking the problem in a broader way. Rapid strides were made in the early days of the industry by trying daring innovations, and he believes that body engineering can be greatly advanced through larger appropriations by manufacturers for research and development work, which would contribute greatly to the general progress of the industry.

Following the presentation of his paper, Mr. Hibbard, at the request of Chairman H. C. Crecelius, illustrated on the blackboard a number of details of his firm's methods of body construction and carefully explained them, to the obvious interest of members in the audience, several of whom asked questions to elicit more thorough explanation. One interesting point mentioned by Mr. Hibbard was that he had been "flirting" with the idea of using cork for the center of the roof, a material that was used on an interesting body built by a Brussels coach builder and displayed at the Paris salon. In this, a wood frame was covered with a ground-cork composition similar to linoleum, which was used in varying thicknesses according to the part of the body covered and was molded nicely around the corners. The entire body was primed and finished with cellulose, so that it looked just like a metal body and had the advantage of being light and a sound insulator. It was also unaffected by climatic conditions, and was warm in cold weather and cool in hot weather.

Before the next paper was presented, Chairman Crecelius called for nominations of men to be elected by the Passenger-Car-Body Activity as a nominating committee to elect a Vice-President to represent the Activity in 1931. The following were nominated and unanimously elected:

C. L. Hill, K. C. Haven, A. L. Knapp and W. N. Davis.

The Fundamental Cause of Trouble

Body mounting is a problem that produces friction, movement and noise, not only in the bodies themselves, but in sales departments, engineering offices and design staffs, remarked E. C. Gordon England, chairman of the Gordon England Co., of England, who delivered the next paper. The whole problem develops into a matter of great magnitude fundamentally because the accepted practice of mounting the body has been to attach it to the chassis and to the dash by a series of bolts or set-screws, and to attach the hood, fenders and running boards partly to the chassis and partly to the body.

The chassis engineer has devoted much thought to producing an automobile that is as quiet, smooth and restful as it is possible to conceive and construct, but this state of well-being is constantly being upset, said Mr. England, by intermittent noises in what is sweepingly regarded as the body. Also, in some cases a periodicity that is almost unnoticeable in the chassis becomes amplified by that sound magnifier, the body. The problem that has faced the industry in all lands for many years is to control this undesirable feature. Therefore it seems surprising that no fundamental attack has been made upon the root of the trouble.

The nature of the conventional chassis is that of an elastic and flexible unit, whereas the nature of the body is that of an almost inelastic unit, except in those directions in which the body designer would welcome an infinite degree of inelasticity, and here it fails lamentably. The mating of these two parties of quite definite incompatibility, declared the speaker, must lead to that same unfortunate result that is witnessed in the human union where incompatability exists. Herein lies all of our trouble. The body, when mounted on the chassis, is subjected to relative movement in its parts, and these in time produce noise. To correct this, the body builder has built his bodies more and more substantial, until the chassis designer has been staggered by the weight of the superstructure imposed on the chassis.

Three European Methods of Attack

Instead of following the American line of development of jointless pressed-steel bodies to prevent rattles and squeaks, the European builder has proceeded along a different line of attack because of the peculiar laws and conditions that place a premium on cars of light weight and small size. Body engineers there are in almost complete agreement that the chassis *is* a flexible and elastic base for the body, but they are divided in opinion whether to make the body also flexible, so strong and rigid that it will make the base rigid, or introduce some form of insulation between the two components of the complete car.

Typical examples of ways in which each of these schools of thought has worked out its ideas were given by Mr. England, who, as an advocate of the third line of reasoning, devoted most of the latter part of his address to a description of the construction followed by his company, which was illustrated with slides. The body shell is made as a rigid, sill-less unit and is attached to the chassis at three points, at which provision is made for a very limited amount of movement. The hood dash is free from the body shell and the seats are attached to the chassis but not to the body. Thus the body shell floats unstressed on its three points of support and no torsional movement of

the chassis frame is communicated to the body. The result is that a body of extraordinary lightness can be built and, owing to freedom from relative movement between its parts, is completely and permanently silent.

Aluminum is regarded by Mr. England as the ideal material for body construction because of its light weight and comparative lack of resonance. An all-steel body that weighs 1000 lb. could be built in aluminum at a weight of only 600 lb., and this saving in body weight would permit of reducing the chassis weight. The extra cost of the material would be more than offset by the higher price the customer would be willing to pay to get the greatly improved performance of the lighter car.

More Details Requested

Members asked numerous questions after the conclusion of Mr. England's address, specifically about details of construction and actual weight-saving. Chairman Crecelius remarked that he believes that this construction goes a long way toward correcting the troubles caused by the flexibility of the chassis, such as squeaks and rattles.

E. H. Brill, of the Hudson Motor Car Co., asked about the relative movement between the body sides and the passengers and between the rear seat attached to the floor and the seat back attached to the rear body-panel. To this, Mr. England replied that the average amount of movement that could be observed on second-class roads was from ⅛ to 3/16 in. and that it is impossible for the passengers to notice this. The movement of the passenger on the seat cushion is as much as 2 in., hence the slight movement of the seat back and the body shell does not affect the passengers.

Past-President W. G. Wall referred to the Arrow trailer type of construction as having great possibilities. These trailers, which can be attached to a roadster or other car, are rather long, usually contain six or eight wicker chairs, weigh about 1200 lb. and ride very comfortably. They are made extremely rigid by following the methods of airplane-fuselage construction, using diagonal tension members, so that the posts and compression members can be made small. The covering could be of fabric or any desired material.

W. E. England, formerly chief engineer of the F. B. Stearns Co., told of tests made by that company to learn the precise cause of body noises and front-end wabble and shimmy. The result was that the chassis was redesigned and stiffened so that all the troubles were overcome. His own belief, therefore, is that the problem is being attacked from the wrong end and that the chassis should be made rigid. Mr. Gordon England, however, cited the British Lanchester chassis, which is very rigid and provided with torque members to take the torsion stresses, yet which, when subjected to an 18-in. distortion, went definitely out of shape about ½ in., which is enough to wreck the finest body ever made.

Weight Reduced 200 to 800 Lb.

L. C. Hill, of the Murray Corp. of America, asked for some definite figures on weight saving by the Gordon England method of construction. Exactly 200 lb. was saved, asserted Mr. Gordon England, on a body built for the Erskine in England, which was slightly larger than the regular body and had safety glass instead of plate; the same fenders, cowl and dash were used. On Chrysler bodies, which also were slightly larger, the saving was 380 lb. The reduction in weight of bodies built for the Rolls-Royce amounted to 810 lb., using the same specifications as for other bodies. One of these bodies has been used for 50,000 miles on Continental roads and was said to be still free from rattles.

The session was concluded with the presentation by Dr. Kelley of the paper on sheet-metal body fabrication as practised by the Budd company and the showing of the motion pictures. This paper is published in this issue of THE JOURNAL, beginning on p. 169. Unfortunately, inventive genius has not yet found a way of reproducing motion pictures in periodicals; otherwise the report of this session of the Annual Meeting might be made the most absorbing of all the reports.

Annual Business Meeting Action

Committee Reports Approved, Nominating Committee Members Elected, New Officers Announced and Constitutional Amendments Submitted

THE adjourned Annual Business Meeting convened Monday evening, Jan. 20, in the crystal room of the Book-Cadillac in Detroit, with President Strickland in the chair. The annual reports of the administrative and technical committees, as printed in pamphlet form for distribution at the meeting, were presented without reading, and the chairmen of the several committees were called upon successively to rise to be recognized. Upon motion made and seconded, the reports of the Membership, Publication, Production, Research, Sections, and Transportation Committees and of the Treasurer were approved.

Chairman Scaife, of the Standards Committee, then made a statement regarding several minor changes in the recommendations of the Standards Committee Divisions, and recommended that, with these few changes, the report of the Standards Committee be approved. The motion was seconded and carried.

Following an explanation of the procedure of electing members to the Nominating Committee of the Society in accordance with changes in the Constitution finally adopted following the Semi-Annual Meeting last year, Mr. Clarkson read the names of members and alternates of the committee designated by qualified Sections, as follows:

Section	Representative	Alternate
Buffalo	E. W. Kimball	W. Edgar John
Canadian	R. H. Combs	A. S. McArthur
Chicago	R. E. Plimpton	B. S. Pfeiffer
Cleveland	J. Webb Saffold	E. M. Schultheis
Dayton	Carl H. Kindl	Rodger J. Emmert
Detroit	P. J. Kent	B. J. Lemon
Indiana	L. Schwitzer	H. C. Snow
Metropolitan	Herbert Chase	Geo. Margolin
Milwaukee	W. A. Starck	A. W. Pope, Jr.
New England	Albert Lodge	J. A. Moyer
Pennsylvania	J. P. Stewart	C. O. Guernsey
So. Calif.	John H. Watrous	Eugene Power
Washington	C. S. Fliedner	E. S. Pardoe

Other alternates were E. Wooler (Cleveland), M. R. Wolfard (New England), and C. S. Bruce (Washington).

Nomination and election of three members-at-large to serve on the Nominating Committee, with the members or alternates elected by the Sections, for the purpose of nominating candidates for the presidency, the office of treasurer, and three councilorships, beginning with 1931, was declared in order. B. J. Lemon, Vincent C. Apple and Dr. H. C. Dickinson were elected as the three members-at-large.

It was explained that the Nominating Committees of the Professional Activities would be elected by the respective Activities at business sessions to be held on following days of the

Annual Meeting. The function of these Nominating Committees is to select candidates for the Vice-Presidencies representing the respective Activities during 1931. Subsequently, these members of the Nominating Committee were elected as follows:

DIESEL ENGINE ACTIVITY

Members	Alternates
N. H. Gilman	L. F. Burger
J. H. Hunt	Harte Cooke
A. J. Poole	
A. C. Salisbury	

MOTOR-TRUCK AND MOTORCOACH ACTIVITY

Members	Alternates
B. B. Bachman	F. Jehle
G. A. Green	C. A. Peirce
C. F. Magoffin	
A. F. Masury	

PASSENGER-CAR ACTIVITY

Members	Alternates
W. J. Davidson	W. T. Fishleigh
T. J. Litle	F. F. Kishline
H. T. Woolson	

PASSENGER-CAR-BODY ACTIVITY

Members
W. N. Davis
K. C. Haven
L. C. Hill
A. L. Knapp

PRODUCTION ACTIVITY

Members	Alternates
E. P. Blanchard	J. M. Crawford
L. A. Churgay	Alex Taub
A. R. Fors	
V. P. Rumely	

TRANSPORTATION AND MAINTENANCE ACTIVITY

Members	Alternates
Donald Blanchard	T. L. Preble
H. W. Middleworth	A. J. Scaife
Pierre Schon	
E. W. Templin	

Election of Officers Announced

Secretary Clarkson read the report of the Tellers of Election for 1930 and announced the election of Officers as published in the January issue of THE JOURNAL and announced at the Annual Dinner in New York City on Jan. 9.

President-Elect Edward P. Warner, who was inducted into office at the close of the Annual Meeting, made brief remarks.

Constitutional Amendments Adopted

Mr. Apple, Chairman of the Sections Committee, moved the adoption of amendments to Sections C 21 and C 21a of the Constitution as printed in the S.A.E. JOURNAL for January and as reprinted and distributed at the meeting. These, if adopted, would fix the annual dues of Members, Associates and each Affiliate Member Representative at $20, Service and Foreign Members at $15, and Junior Members at $10, and provide that the Society shall turn over to each Section a part of the dues paid by each Member, Associate and Affiliate Member Representative residing in the territory of each Section as defined by the Council. These amendments, said Mr. Apple, had been before the Sections Committee for some years and had been considered by the Council at numerous meetings. In seconding Mr. Apple's written proposal, W. T. Fishleigh stated that it had also been approved by the Council and that their submission at this meeting was merely a formality to bring the proposed amendments before the voting membership for further consideration at the Semi-Annual Meeting.

Councilor Orrel A. Parker brought up as another new matter of business the recommendations of the Student Branch Committees regarding the Student Enrollment, as embodied in proposed amendment of Section C 52. The proposed amendment, which differs slightly from the form in which it was printed in THE JOURNAL for January, was read by Mr. Parker, as follows:

C 52. The Council may further, in its discretion, authorize the enrollment, individually or by group, of persons under 30 years of age who, at the time of application, shall be bona fide students of a recognized institution of engineering or pursuing an approved course of study in automotive engineering. Student enrollment may be for the duration of the student's recognized or approved course plus one year thereafter, but in no case for longer than five years.

The Council shall determine the amount of the annual enrollment fee. Enrolled students shall not be Members of the Society, nor be entitled to vote or hold office.

If this amendment is adopted, references to student enrollment in Sections C 20 and C 21 are to be omitted.

President Strickland announced that the motion to approve the amendment had been seconded, that it had been discussed and looked upon with approval by the Council, but must go through the regular channel, coming up for further consideration at the Semi-Annual Meeting.

Thereupon the business meeting was adjourned and the rest of the evening session turned over to the Production Session, with Edward P. Warner in the chair.

Production Committee Plans

AT THE meeting of the Production Activity Committee, held on Tuesday afternoon, plans were outlined for holding National Production Meetings of the Society and cooperating with Sections of the Society, especially those in the larger production-centers, for holding Section production meetings during the year. Further development of these plans was referred to the Meetings Committee of the Production Activity Committee, of which J. A. Geschelin is Chairman.

The proposal is to hold two National Production Meetings each year, one in the spring, preferably about May, and the other in October. The spring meetings would be held in various production centers from year to year, preferably in conjunction with the local Sections, to distribute these meetings in as large a territory as possible. The October Production Meeting would be held in Detroit each year, as it is believed that production engineers and executives can attend a meeting at that time better than at any other time in the year.

Spring Meeting in Chicago

It was planned to hold the 1930 spring meeting in Chicago next May, with the cooperation of the Chicago Section.

Plant visits at the time of the Production Meetings will be arranged for to make the meetings more valuable.

The Committee agreed that papers for presentation at Production Meetings should be entirely technical and concerned primarily with the economic problems of manufacturing.

A bibliography of production papers and articles printed in THE JOURNAL is to be prepared and sent to production executives, accompanied by a personal letter outlining the organization and activities of the Society, particularly the Production Activity, to inform them more fully regarding the Society's work in production engineering.

An Executive Committee was appointed to carry on the regular work of the Production Activity Committee and cooperate with the Meetings and the Membership Committees in their work. Meetings of the entire personnel of the Production Activity Committee probably will be held only at the time of the National Production Meetings.

The members of the Executive Committee are John Younger, Chairman; J. W. Brussels, Vice-Chairman; David Ayr, A. R. Fors, J. A. Geschelin, W. W. Nichols, V. P. Rumely and F. W. Stein.

An important decision arrived at in the plans of the Committee was that its Meetings and Membership Committees should cooperate with the Chairmen of similar Committees of other activities of the Society, in the interests of the production engineers and executives in all branches of the automotive industries represented by the other Activities of the Society.

Those in attendance were:

John Younger, Ohio State University, Chairman
A. R. Fors, Continental Motors Corp.
J. Geschelin, *Automotive Industries*
W. W. Nichols, D. P. Brown & Co.
V. P. Rumely, Hudson Motor Car Co.
F. W. Stein, Fairbanks, Morse & Co.
C. F. Clarkson, General Manager, S.A.E.
R. S. Burnett, Manager, Standards Department, S.A.E.

Sections Committee Meeting

THE first meeting of the 1930 Sections Committee, together with some of the representatives of the 1929 Committee, was held on Wednesday, Jan. 22, with the new Chairman, B. J.

Lemon, presiding. Representatives of eight Sections and one member-at-large took part in the discussion of the various problems involved in the Sections work for this year.

The question of Section finances, with particular reference to the method to be followed in collecting and transmitting Section dues to the Sections under the new plan now under consideration, and the proper apportionment of expenses on the new budget-forms, were discussed.

The Committee was informed of the recent formation of the two new probationary Sections, namely, the Oregon Section and the Twin City Section, the former centering its activities in Portland, Ore., and the latter in St. Paul and Minneapolis. An outline of the work in progress in Syracuse and Baltimore, with a view to the formation of Sections in those cities, was also given; and the suggestion of a member from Tulsa, Okla., that steps be taken to assist in the formation of a Section in that locality was transmitted to the Committee. Data are to be sent to O. E. Eckert, of the Independent Oil & Gas Co., of Tulsa, showing the number of members and prospective members in the Tulsa territory so that, if desired, a committee can be organized to investigate the possibilities further. No definite action was taken by the Sections Committee on any of this work.

Requirements for New Sections Rescinded

In 1923 the Sections Committee adopted a regulation covering the number of members necessary in a territory before a probationary Section could be formed, but since that time it has been found that the requirements were somewhat too strict and would, if followed, prevent the formation, in territories that need such activity, of Sections which, if organized, would be productive of additional members in the locality. Consequently, the Committee approved the rescinding of the requirement that the territory have 100 members, 50 of whom are willing to sign a petition and agree to support a Section if organized. The question whether the formation of a Section is justified is somewhat dependent on local conditions, and each case is to be considered on its merits.

Motor-Truck and Motorcoach Activity Committee Meeting

THE first meeting of the new Motor-Truck and Motorcoach Activity Committee was held in Detroit on Friday morning, Jan. 24, to organize its subcommittees and discuss its program of work for the present year. A. J. Scaife, Vice-President of the Motor-Truck and Motorcoach Activity and Chairman of the Committee, announced the appointment of G. B. Ingersoll as Vice-Chairman of the Committee. He also announced that E. M. Schultheis had accepted the chairmanship of the Activity Meetings Committee and A. W. Herrington had consented to serve as chairman of the Activity Membership Committee. Chairman Scaife will appoint the other members of these Committees after conferring with their respective chairmen.

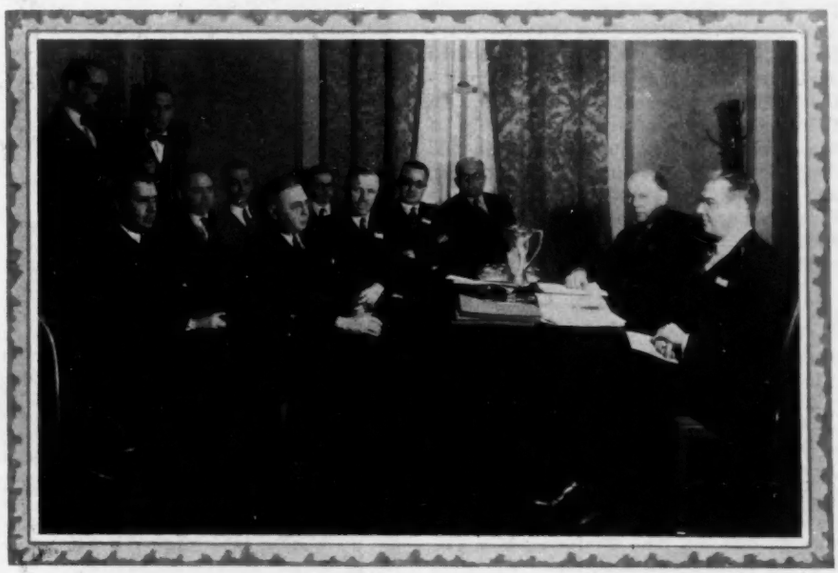
Discussion of the meetings program of this Activity for the year developed the sentiment that its technical sessions should be held only at the Annual and Semi-Annual Meetings of the Society, with one technical session at the National Transportation Meetings, devoted to subjects prepared by the Motor-Truck and Motorcoach Activity Committee. It was felt that the Committee should cooperate with local Sections, especially those located in rather large motor-vehicle transportation centers, in holding at least one Section meeting each year devoted to topics relating to the Motor-Truck and Motorcoach Activity.

There was considerable discussion of the Uniform Motor Bus Specifications Code sponsored by the Motor Vehicle Conference Committee and its relation to the Society's work, especially the S.A.E. Recommended Practice for Motorcoach Specifications printed in the S.A.E. HANDBOOK. A subcommittee of the Activity Committee was appointed to give further study to this subject in cooperation with a similar subcommittee appointed by the Transportation and Maintenance Activity Committee.

The paper presented by Pierre Schon at the Transportation Conference Session on Thursday afternoon was discussed at some length, especially in connection with the suggestions therein for study by the Society's Standards Committee toward the formulating of definite S.A.E. Standards for motorcoaches and motor-trucks. One of the major problems before the motor-truck manufacturers, it was conceded, is the introduction of balloon tires on motor-trucks and their relation to chassis-frame widths and over-all vehicle widths as specified in motor-vehicle regulations or in legislation now in force in almost all of the States. A subcommittee was appointed, with Mr. Ingersoll as Chairman, to study particularly the balloon-tire problem and to make recommendations as to other motor-truck and motorcoach standards that should be considered by the Society.

The following were in attendance at the meeting:

A. J. Scaife, The White Co., Chairman



MOTOR-TRUCK AND MOTORCOACH ACTIVITY COMMITTEE MEETING

G. B. Ingersoll, Federal Motor Truck Co., Vice-Chairman

Frederick W. Heckert, V. G. Apple Laboratories

A. H. Wood, General Motors of Canada

J. E. Hale and J. W. Shields, Firestone Tire & Rubber Co.

K. D. Smith, Goodrich Tire & Rubber Co.

B. J. Lemon, United States Rubber Co.

C. L. Wenzel, Budd Wheel Co.

Rodman S. Reed, Brockway Motor Truck Corp.

M. C. Horine, Mack Truck Co.

A. A. Bull, Handy Governor Corp.

R. S. Burnett, Manager, Standards Department, S.A.E.

Lighting Division Meeting

A MEETING of the Lighting Division of the Standards Committee was held in Detroit on Monday morning, Jan. 20, to consider several criticisms that had been received regarding the Division's report on Laboratory

Tests of Optical Characteristics of Electric Head-Lamps for Motor-Vehicles. These criticisms had been sent to the Society subsequent to the meeting of the Division on Dec. 18, at which the specification had been approved.

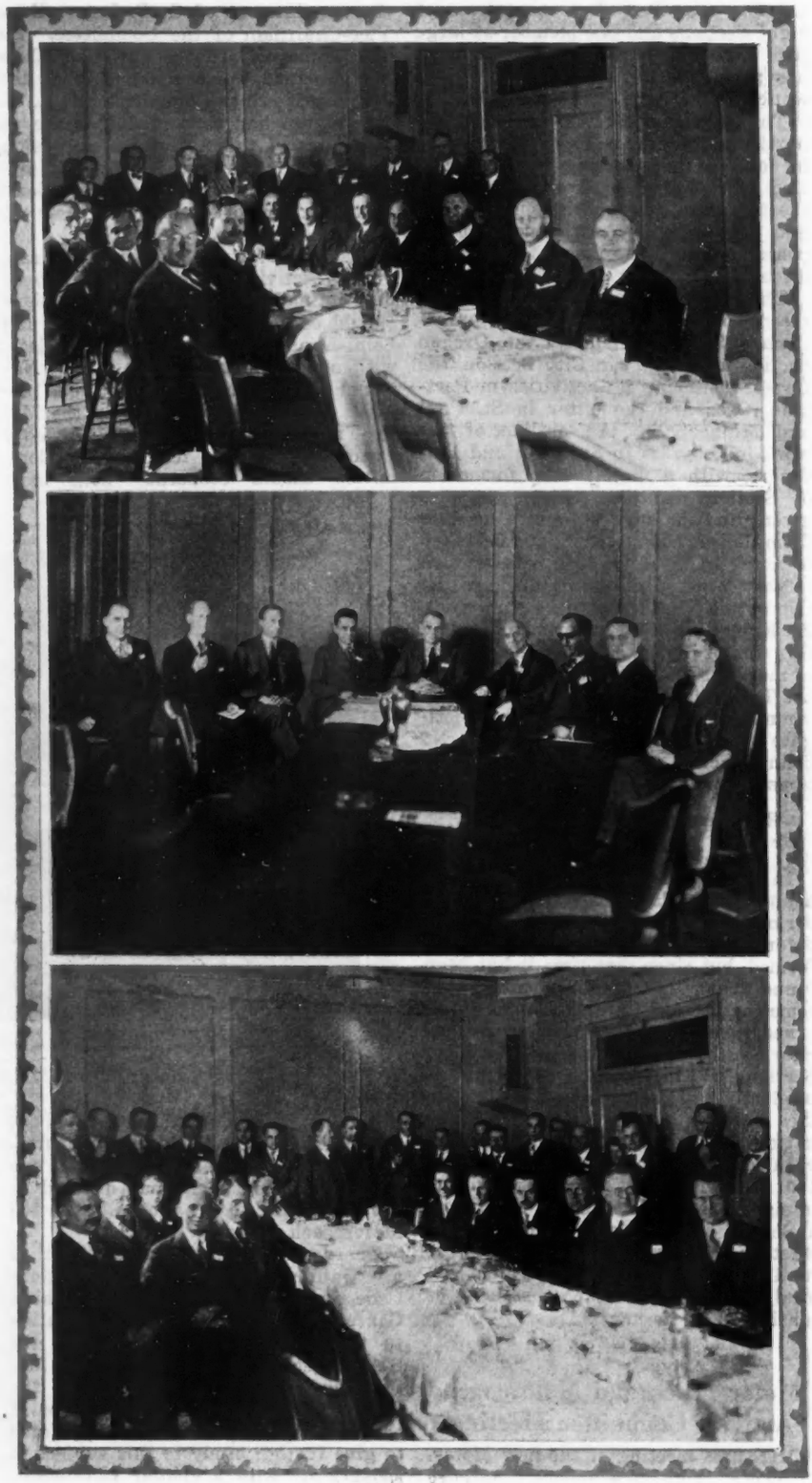
The criticisms related to the specification for the maximum permissible candlepower in the lower beam of headlamps and to the limiting requirements set forth in other paragraphs of the proposed specification. They had been taken up with representative members of the Motor-Vehicle Lighting Committee of the Illuminating Engineering Society, with which the Division has cooperated in formulating the specifications, and virtual assurance was received that changes made in the specifications to meet the criticisms would be satisfactory to the I. E. S. Committee. Accordingly, at the Division meeting several changes were made in the proposed specification printed on pp. 22 and 23 of Section 2 of the January issue of THE JOURNAL in the reports of Divisions to the Standards Committee. The changes that were made in the report are described more fully in the account of action taken on the reports by the Standards Committee, as printed in the Standardization Progress section of this issue of THE JOURNAL.

Those in attendance were:

C. A. Michel, Guide Lamp Corp., Chairman
C. C. Bohner, Tung-Sol Lamp Works
W. H. Bretzlaff, John W. Brown Mfg. Co.
L. R. Chittenden, Allied Products Corp.
L. K. Cohn, representing G. P. Doll, T. J. Corcoran Lamp Co.
H. C. Doane, Buick Motor Co.
R. N. Falge, General Motors Corp. Research Laboratories
W. S. Haggott, Packard Electric Co.
C. L. Holm, Ford Motor Co.
R. W. Johnson, John W. Brown Mfg. Co.
W. M. Johnson, National Lamp Works
A. R. Lewellen, Chevrolet Motor Co.
A. L. Martinek, C. M. Hall Lamp Co.
D. M. Pierson, Chrysler Corp.

1930 Transportation and Maintenance Activity Committee Meeting

THE first meeting of the 1930 Transportation and Maintenance Activity Committee was held in Detroit on Thursday morning, Jan. 23. Chairman F. C. Horner announced the appointment of J. F. Winchester as Vice-Chairman of the Committee for the year and described briefly the reorganization of the Committee under the revised Constitution of the Society. He then reviewed the recommendations of the 1929 Transportation Committee to the 1930 Committee with regard to continuing the study of subjects scheduled to the former Committee. After accepting these recommendations, the fol-



(TOP) SECTIONS AND MEMBERSHIP COMMITTEES DINNER MEETING

(CENTER) COOPERATIVE FUEL-RESEARCH MEETING

(BOTTOM) LUNCHEON MEETING OF FUELS SUBCOMMITTEE AND DIESEL-ENGINE ACTIVITY COMMITTEE

(Top) Luncheon Meeting of the 1929 Council on Monday

(Center) Meeting of the Production Activity Committee

(Bottom) Dinner Meeting of the Meetings Committee

lowing Subcommittees were decided upon for this year's work:

Activity Meetings Committee—Adrian Hughs, Jr., Chairman

Activity Membership Committee—F. K. Glynn, Chairman

Motorcoach Code Subcommittee—E. S. Pardoe, Chairman

Motor-Truck Standardization Requirements Subcommittee—J. F. Winchester, Chairman.

It was decided to continue the Subcommittee on Operation and the Subcommittee on Maintenance, but appointment of the chairmen and members of these Subcommittees was deferred for further conference by Chairman Horner and Vice-Chairman Winchester, of the Activity Committee.

Plans for Transportation Meetings

Tentative plans for Transportation Meetings and technical sessions during the year were discussed and a recommendation was made to the Activity Meetings Committee that it cooperate with the geographical Sections of the Society, especially those in the larger centers of motor-truck and motorcoach fleet-operation. With regard to the Summer Meeting this year, it was recommended that plans be made for devoting one entire technical session to transportation and maintenance activities, with the cooperation of the Motor-Truck and Motorcoach Activity.

The Committee decided that the National Transportation Meeting should be held in the autumn, as heretofore, and that as all of these meetings have heretofore been held in localities convenient only to those east of the Mississippi River, careful consideration should be given to holding a National Transportation Meeting, possibly in the spring, on the Pacific Coast or in the Rocky Mountain district for the far western members and fleet operators. It was suggested that possibly such a meeting could be sponsored by one of the Pacific Coast Sections. An important decision made by the Committee was that the National Transportation Meetings should not be held jointly or concurrently with meetings or conventions of other organizations.

Those in attendance were:

F. C. Horner, General Motors Corp., Chairman

Donald Blanchard, Chilton Class Journal Co.

O. M. Brede, General Motors Truck Co.

H. Dakin, Michigan Bell Telephone Co.

A. D. Ferguson, Canadian National Railways

F. K. Glynn, American Telephone & Telegraph Co.

A. H. Gossard, Middlewest Utilities Co.

T. S. Kemble, of St. Louis

F. C. McManus, representing A. F. Masury, International Motor Co.

H. V. Middleworth, Consolidated Gas Co. of New York City

E. S. Pardoe, Capital Traction Co.

R. E. Plimpton, *Bus Transportation.*

Pierre Schon, General Motors Truck Co.
J. F. Winchester, Standard Oil Co. of N. J.
C. F. Clarkson, General Manager, S.A.E.
R. S. Burnett, Manager Standards Department, S.A.E.

1929 Transportation Committee Meeting

A FINAL meeting of the 1929 Transportation Committee was held Wednesday morning, Jan. 22, to review the reports of several subcommittees on work that had been in progress during the year and to prepare such recommendations as the Committee felt should be considered by the 1930 Committee.

A. S. McArthur, Chairman of the Subcommittee on Operation, submitted reports by members of his Subcommittee as follows:

E. D. Merrill—Report on Proper Speeds—Maximum; Rates of Acceleration and Deceleration; and Overall Speed.

S. B. Shaw—Report on Standardization of Body-Builders' Dimensions.

Eugene Power—Progress reports on Personnel Training.

E. W. Templin—Progress report on Ways and Means of Operating Scattered Fleets.

W. J. Duffy—Progress report on Suitability of Equipment.

Chairman J. F. Winchester of the Subcommittee on Maintenance, submitted reports by the members of his Subcommittee as follows:

E. S. Pardoe—Report on Crankcase Oil Reclaiming.

H. V. Middleworth—Report on Self Maintenance as Compared with Service-Station Maintenance.

E. C. Wood—Report on Preventive Maintenance in line with the Elimination of Mechanical Road Delays.

Mr. Winchester also reported that Eugene Power had not been able to complete his report on Depreciation of Motor-Vehicle Equipment, and recommended that this study be continued this year.

In submitting his own report on Chassis Record Forms, that had already been sent to the members of the Committee, Mr. Winchester stated that this had been circulated also among a large number of motor-truck manufacturers and fleet operators and that apparently it meets with general approval.

Mr. Winchester also reported on the study that has been given to developing suitable forms for A Uniform Method of Cost Comparison, and recommended that a definite form, based on the report by L. V. Newton at the Society's Transportation Meeting in Newark in October, 1928, be submitted to the Society for adoption as S.A.E. Recommended Practice, together with supplementary definitions of what is included in the terms used in the report.

All of the reports were approved and referred to the 1930 Transportation and Maintenance Activity Committee.

It was felt that the report on Training of Mechanics, that had been submitted by T. D. Preble, carried this subject as far as it was possible for the Committee to go and it was voted to regard this subject as completed.

Recommendations on Motorcoach Specifications

Another subject that has been before the Committee for some time is the study of the proposed Uniform Motor-Bus Specifications Code, which is sponsored by the Motor Vehicle Conference Committee. In this connection it was recommended that the present Motorcoach Specifications printed in the 1929 edition of the S.A.E. HANDBOOK be cancelled as obsolete and that the 1930 Transportation Committee continue study of the subject and of the question whether a substitute specification can be adopted for publication in the HANDBOOK in place of the present specification.

F. C. Horner, Chairman of the Transportation and Maintenance Activity Committee, and A. J. Scaife, Chairman of the Motor-Truck and Motorcoach Activity Committee, represent the Society on an advisory subcommittee to the Motor Vehicle Conference Committee with regard to possible modifications of the present code from time to time. The 1929 Transportation Committee recommended that two additional members representing fleet operators be named to serve on this advisory subcommittee, suggesting E. S. Pardoe and L. H. Palmer for such appointment by the Council.

Chairman Horner reviewed briefly the work of the Committee during the last few years, especially the accomplishments during 1929, and thanked the members of the Committee for their work and others who had cooperated with them in maintaining active interest of the fleet operators toward enabling the Committee to accomplish what it has done during the year.

Those in attendance were:

F. C. Horner, General Motors Corp., Chairman
Donald Blanchard, Chilton Class Journal Co.
Henry Dakin, Michigan Bell Telephone Co.
F. K. Glynn, American Telephone & Telegraph Co.
A. H. Gossard, Middlewest Utilities Co.
H. W. Kizer, The Texas Co.
Edward Lowe, Handy Governor Corp.
A. S. McArthur, Toronto Transportation Commission
H. V. Middleworth, Consolidated Gas Co.
E. S. Pardoe, Capital Traction Co.
A. J. Scaife, The White Co.
Pierre Schon, General Motors Truck Co.
J. F. Winchester, Standard Oil Co. of N. J.
D. C. Vandercook, International Correspondence Schools
C. F. Clarkson, General Manager, S.A.E.
C. B. Veal, Research Manager, S.A.E.
R. S. Burnett, Standards Manager, S.A.E.

Publication Committee Recommendations

SEVERAL matters pertaining to THE JOURNAL and TRANSACTIONS were considered at a Tuesday luncheon meeting of members of the Publication Committee, at which the following were present:

John Younger, Chairman; W. Laurence LePage and J. F. Winchester, appointees on the Committee for 1930; President-Elect Warner, Chairman of the Publication Committee prior to 1929; Secretary and General Manager Clarkson; F. L. Faurote, publicity manager of the Society; and H. W. Perry, of the publication department.

Chairman Younger presented a statement of the status of the work, showing that the publication of TRANSACTIONS is now right uptodate, papers and discussions published in all issues of THE JOURNAL in 1929 having been approved or disapproved for inclusion in the volume of TRANSACTIONS to be published for 1929. This list shows 90 papers, with discussion, approved and 34 disapproved, representing a larger percentage approved than in preceding years. The volume of TRANSACTIONS for 1929 is expected to be issued early in the spring.

Silver Anniversary Number

As the Summer Meeting next May will mark the 25th anniversary of the organization of the Society, the question of issuing a special Silver Anniversary Number of THE JOURNAL was discussed and a motion was made and carried that:

The Publication Committee recommends to the Council that a special number of THE JOURNAL be issued to celebrate the 25th anniversary of the Society.

It was understood that this special number should preferably be the June issue containing the news report of the Summer Meeting and that as features it might have a silver-paper cover and contain an historical review of the organizing and the activities of the Society from its beginning, perhaps tying in its accomplishments with major developments in the automotive industry.

With a view to securing for Section meetings papers of permanent value on subjects of importance, the Committee discussed the desirability of recommending to the Meetings Committee of the Society that suggestions be offered to the Sections officers regarding subjects suitable for papers and recommendations regarding qualified authors available. This was with the idea that more Section papers

would thus become available for permanent preservation in TRANSACTIONS. The Committee was agreed that only papers of permanent engineering value should be printed in TRANSACTIONS. No formal action was taken regarding a recommendation to the Meetings Commitee.

Chairman Younger presented a brief statement showing an average increase of 30 pages of text per issue in THE JOURNAL since September, 1929, over the corresponding issues a year ago, as authorized by the Council at the 1929 Semi-Annual Meeting, and the Committee discussed the adequacy of this increase to provide for the publication of desirable papers and discussion presented at meetings of the Society and the Sections.

1929 Screw-Threads Division Meeting

ON MONDAY morning, Jan. 20, the Screw-Threads Division of the Standards Committee held a meeting jointly with Subcommittee 3 of the Sectional Committee on Bolt, Nut and Rivet Proportions at which it was recommended to the Standards Committee that the Sectional Committee's report on Slotted-Head Machine, Cap and Wood-Screws be approved for adoption as American Standard and also S.A.E. Standard. This report includes detail specifications for flat-head, round-head, oval-head and fillister-head machine-screws, with a table of the preferred lengths for each type; flat-head, button-head and fillister-head cap-screws, together with specifications for their lengths, thread lengths and screw points; and tables for flat-head, round-head and oval-head wood-screws, with tables of lengths of these screws in both brass and steel.

The Division also voted to appoint a Subdivision of the screw-threads Division to prepare a supplementary table of round-head machine-screws with head dimensions somewhat smaller than those given in the Sectional Committee's report, as screws with the smaller heads are used to a considerable extent in the automobile industry.

The Sectional Committee recently submitted its report on Track Bolts and Nuts for approval by the Society as a sponsor, at the Jan. 20 meeting and the Division recommended that the report be approved for adoption only as American Standard, as this class of product is not used by the automotive industries.

Those present at the joint meeting were:

E. H. Ehrman, Standard Screw Co., Chairman
L. Barber, National Screw & Mfg. Co.
J. S. Black, Corbin Screw Corp.
A. Boor, Willys-Overland Co.
E. J. Bryant, Greenfield Tap & Die Corp.
H. E. Geoppel, Mason Phelps and E. M. Whiting, Pheoll Mfg. Co.
R. M. Heames, Allied Products Corp.
W. M. Horton, Lamson-Sessions Co.
C. B. LePage, American Society of Mechanical Engineers
A. E. Norton, Harvard University
W. J. Outcalt, General Motors Corp.
C. H. Palmer, National Screw & Mfg. Co.
E. W. Reed, Reed & Prince Mfg. Co.
G. W. Thurston, American Screw Co.
O. B. Zimmerman, International Harvester Co.
R. S. Burnett, Manager, Standards Department, S.A.E.

A World on Wheels

NOTWITHSTANDING the fact that the world is becoming airminded, it still keeps on the ground and travels more and more on American-made wheels.

That the world is taking to wheels is shown by comparison of official estimates of automobile registrations. As of Jan. 1, 1929, the world total was 32,058,500 automobiles. On a per-capita basis the ratio would be 1 automobile to 61 persons. In 1928 the ratio was 1 to 64, in 1927 it was 1 to 66 and in 1926, if all the world took a ride at the same time, it would be necessary to crowd 71 persons into every automobile. As the ratio outside of the United States is still very large, being 247 persons to 1 automobile, there is still a wide field for cultivation.

It would be folly to suggest the possibility of that 247-to-1 ratio being reduced to a parity with the United States, which is 4.87 to 1. But a generation that within the first two-thirds of its span has seen the Chinese discard their queues and the Turkish women their veils can hope to see the automobile make considerable progress in displacing the camel and donkey as means of transportation in some parts of the world. In fact, the American automobile is already doing that. It is making steady progress in Egypt, Turkey, Syria, Africa and China, and it would be difficult to find a country between the Arctic and Antarctic circles that it has not invaded.

Low purchasing power and poor roads are the principal handicaps, not only in the backward countries but also in the highly civilized ones. Increased use of automobiles keeps pace with improvement in purchasing power and extension of roads. The steady increase in the number and value of our exports shows, too, that the American automobile is finding favor everywhere. In the last year these exports have stood at the head of the list in value of finished manufactures. Recently machinery has been making wonderful strides, and now these two export racers are running neck and neck. On account of the large amount of labor involved in their manufacture, exports of both machinery and automobiles are of great importance, and to each the outside world seems to offer a field that will respond to intensive cultivation. It is probable also that the more the world makes use of our machinery, the more it will be able to ride on our wheels.—*Barron's.*

Met-Section Show Analysis

Developments in Engines, Chassis and Bodies Outlined and Talk on Selling Given at Dinner Meeting

APPROXIMATELY 500 members and guests attended the annual Automobile Show meeting and dinner of the Metropolitan Section in the east ballroom of the Commodore Hotel, New York City, on the evening of Jan. 6. After the lamb-chop dinner, during which the guests visited one another and inspected their prize packages of advertising novelties, Past-Chairman Sidney R. Dresser introduced the entertainers. These were the Misses Hale and Holiday, an athletic pair of dancers who gave two very pleasing numbers, and Messrs. Whelan, Noll and Kenney, featured as the Gold Dust Twins, and their accompanist, who gave a line of songs and patter.

Blanchard Reviews Engines

When the applause had sufficiently subsided, Chairman George A. Round introduced Harold F. Blanchard, technical editor of *Motor*, to tell about the engines of 1930 cars. He considered the 16-cylinder Cadillac to be the most interesting engine of the year, and mentioned among its features the cylinder dimensions of 3 x 4 in., giving 452-cu. in. piston displacement; the 5.5:1 compression-ratio; and the fitting of both vacuum tanks and fuel-pumps. The new Hupmobile eight was mentioned for its oil-cooler and Ray Day Tungtite pistons.

Improvements in the Franklin engine are said to increase its horsepower to 95 at 3100 r.p.m., which is high power for any engine of its size. The compression is 5.3:1, and the cooling of the head has been improved by making it of aluminum alloy with the valves side by side transversely instead of longitudinally. This arrangement favors the circulation of air, which passes over the engine crosswise.

The inlet systems of the Graham engines have been improved by making the inlet pipes square and the inlet ports rectangular. In this way the lower side of the port is brought closer to the level of the valve head, being about at the height of the center of the former round port. Other engines mentioned by Mr. Blanchard were the Oakland V-Eight, for its vibration synchronizer and novel combustion-chamber; the new Hudson Eight, with its 5.78:1 compression-ratio; and the new Marmon 78, in which an L-head design has replaced the former I-head.

Chassis Described by Denham

Ascribing a large part of the engineering development of chassis to the manufacturers of units, A. F. Denham, field editor of *Automotive Industries*, described the improvements in chassis for the year. He remarked on a tendency to still further uniformity in general design; clutches, for instance, are almost all of the single-plate dry type excepting those for engines having an exceptionally high torque, in which cases double plates are used to keep down the diameter and the inertia forces. The most noticeable change in clutches is said to be in the wider use of cushion drives. One new design has radial laminated springs and stops, to limit the relative motion of plate and hub. Interleaf friction provides damping. Leakage of oil into the clutch housing has been prevented in one design by a vent in the form of a duct, opening near the center of the housing, to reduce the partial vacuum resulting from the fan effect of the rotating clutch.

Uniformity is not so evident in transmissions, said Mr. Denham, because of the increasing number of four-speed and three-speed units in which exceptionally quiet next-to-top gears are provided. Several gearshift levers have been moved from the transmission case to the flywheel housing, and one or two are mounted on rubber, to reduce the transmission of noise and vibration.

Improvements in rear axles include more accurate machining of gears, to reduce noise; oil scoops, to improve lubrication; and centralizing some bevel-drive gears between bearings. Double bearings at the rear wheels, and treads wider than standard, are becoming the rule. Mr. Denham also believes that the "pie-plate" type of hub cap will prove very useful on camping trips.

Springing and Brakes

Spring rates have been decreased with the growing use of double-acting shock - absorbers, and improvements have been made in spring-bumper equipment. Double shackling of the left front spring is becoming more common, and the same results are obtained in one model by a fairly flexible rubber shackle at the fixed end of the spring. Rubber shackles and bushings are on the increase, including the design in which a section of rubber of large diameter is forced into a smaller sleeve and one in which rubber balls are mounted in steel cups, with shackle pins passing through the balls. Spring covers, many of them metallic, are also being adopted by a number of car manufacturers.

Among the changes in brake design are the more common use of a single central cross-shaft connected to both the pedal and the hand lever. In one such design, the customary central support of the shaft is replaced by a double-link parallelogram between the brake pedal and cross-shaft. Some cross-shafts are provided with lubricant reservoirs or roller mountings. Cable operation of mechanical brakes has become more popular with the development of connections of the Bowden-wire type and cables that are less subject to stretching. Molded brake-lining has become almost universal.

Front drives were referred to by Mr. Denham only in a warning against undigested designs. He believes that nothing else will produce as great resistance to the acceptance of this type of drive as designs not sufficiently worked out.

Hill Demands Soulful Radiators

In introducing L. Clayton Hill, of Dietrich, Inc., Chairman Round said that he had demanded from Mr. Hill information as to whether a long-legged man would still have to contend with low bodies. His challenge was met with: "Yes, we are going to make you like them."

Mr. Hill said that the spotlight has been stolen from the body builders by the oil-splashed engineers, and the appearance of bodies seems to have reached a degree of standardization bordering on stagnation. Cars look so much alike that salesmen cannot tell their own cars at the Shows. One of them made an obviously inaccurate answer in regard to some mechanical feature of the car at his side. When the error was called to his attention, he looked up at the sign on the booth and excused himself, saying that he was supposed to be selling next door. The radiator of the car, according to Mr. Hill, should serve, like a man's face, to distinguish it from other cars. A great obligation rests upon body makers, especially custom builders, to pioneer some new styles; but changes must not be made too abruptly. One object to strive for is an attractive design without molding.

Improvements that are not easily visible have been made in bodies, particularly in the wider adoption of non-shatterable glass, improved finishes, and elimination of squeaks. Mr. Hill prophesied that plated exterior trimmings will soon be obsolete, and that there will be an increasing demand for convertible bodies. He advised that in making new designs, as in adopting style changes in

feminine clothing, the designers should let the chassis be their guide.

Meeting the Problems of Selling

Having the engines, chassis and bodies so well presented, Chairman Round called upon Otis Lucas, of the Studebaker Corp. of America, with the question, "How are all these features to be sold?"

Mr. Lucas said that automobile men were approaching the year in a new frame of mind. Leading executives were in New York City with the idea of actually attending the Show (singular). Just as much thought is going into the selling as into the designing of cars.

Local dealers are still more anxious to sell cars in their communities than are the car manufacturers. If sales fall off in one territory, the dealer can make no profit, but the manufacturer can still secure business from other communities. A great movement is on foot to contribute the aid of the whole organization to the business of helping the dealer to retail cars.

The automobile represents one of the largest purchases made by the average American, ranking after only his home and his investments. The Studebaker corporation has analyzed the reasons that guide a man in making this large investment and has also made a study of the sources of dealers' sales. The main source is the front door, or salesroom; the second is the back door, or service station; the third is the telephone, or friendly tips; and the fourth is the outside work of the salesmen. Engineering that makes the cars more attractive brings more purchasers into the showroom.

Having apparently exhausted the information with which he came, Mr. Lucas turned to some notes that he had taken, as any intelligent salesman should, of the engineering wisdom to which he had been exposed during the evening. He had learned of a power-plant having a volumetric efficiency of 212, which he understood to be the boiling point. The vibration of the car is entirely circular, so it goes completely around the engine and meets. The water-pump has two outlets, in case one of them gets stopped up. The car has practically no pistons, and a guaranteed speed of 112 m.p.h., running before a Texas tornado. Female members of the transmission have missing teeth, and Mr. Hill had described a synthetic undercoating. Wilder trades are the rule. The name of this car, said Mr. Lucas, can be found on any of the automobile advertising pages of the *Saturday Evening Post*.

Becoming more serious again, Mr. Lucas reminded his hearers that in times of adversity new leaders are born. James Cleary, now Studebaker sales manager, wrote a slogan during the depression following the World War which, Mr. Lucas said, quoting it, can be made applicable today, "There is opportunity ahead, and 1930 will reward fighters."

Supercharging and Its Advantages

Buffalo Section Hears Mecklenburg Describe How Three Systems Were Developed

SUPERCHARGERS for automobiles, airplanes and large stationary Diesel engines were discussed at the January meeting of the Buffalo Section. Approximately 100 members and guests attended the meeting, which was held at the Hotel Statler on Jan. 7, and listened to an interesting paper by A. C. Mecklenburg, of Indianapolis. Mr. Mecklenburg was one of the pioneers in supercharger development in this Country and is a firm believer in the feasibility of supercharging internal-combustion engines, especially with the rotary positive-displacement type running at engine speed.

Three different systems, all of which are said to have worked out satisfactorily, were described in the paper. The first of these is one in which the charge was blown through a balanced-type carbureter located between the blower and the engine. The next was a modification of this system, whereby the blower ran continuously and was located between the carbureter and the engine. The most recent arrangement is a combination of the other two, the blower being in the same location as in the second system and equipped with a clutch so that it can be operated when desired, as was the case with the original system.

Earliest System and Its Faults

In the earliest of the systems, the air from the blower picked up the fuel on its passage through the carbureter and delivered it to the engine under pressure. A clutch was provided whereby the blower could be started or stopped at the will of the operator, the engine operating as a normal unsupercharged unit when the blower was inoperative. To relieve excessive air-pressure that might build up when the carbureter throttle was closed and the supercharger was in use, a blow-off valve was located between the two. The objections to this system were noise of the air passing through the blow-off valve, some burning of valves and spark-plugs and a temperature rise that, while not excessive, was unnecessarily great.

Relocation of Blower Overcame Objections

The results obtained with the second system, said Mr. Mecklenburg, were much more satisfactory in every way. With the blower located between the carbureter and the engine and running at all times, the fuel and air were drawn from the carbureter and passed on to the engine under pressure. The valve and spark-plug burning and the temperature rise encountered with the earlier system, were both overcome, probably because the air and fuel, when passing through the whirling impellers of the supercharger, were so thoroughly mixed that a dry, cool charge was delivered to the engine. Thus an increase of 30 per cent in horsepower was secured, with an increase in fuel consumption that did not exceed 3 per cent of the quantity consumed when the engine was operating normally.

To provide for idling and quick acceleration, a device for metering the fuel into the airstream coming from the blower is connected with the main fuel conduit through an outlet close to the intake manifold and an inlet several inches lower. Between these two points is located a weighted check-valve that remains closed during the idling periods, thereby shunting the air coming from the blower and at the same time picking up sufficient fuel for idling the engine. For quick acceleration a needle-valve is provided which is entirely automatic and rises from its seat to admit more fuel in proportion to the opening of the main-carbureter throttle at the same time that the weighted check-valve commences to open. This operation continues until the supercharger comes into play and cuts out the auxiliary device until such time as the system is again working under sub-atmospheric conditions.

Final System Combines Good Features

The third system, which was developed recently, is a combination of the good features of the other two. This system employs the same blower equipped with a manually operated clutch that permits operation when desired. The blower is the same as that used in the second system and is located between the carbureter attached to it and the engine, where another carbureter of the conventional type is placed, a semi-automatic check-valve being located between the carbureter and the manifold. The clapper of this valve is below the terminus of the fuel conduit leading from the blower, and when the latter is in operation under pressure the carbureter attached to the engine is closed off.

No fuel-metering device is provided for idling and acceleration, but an idling jet is located in the supercharger carbureter to keep the engine alive during the decelerated periods while the supercharger is in action. All idling and congested-district driving should be done through the conventional carbureter as mounted on the engine, the change from one system to the other being easily made by manipulating a button on the instrument board.

Three cars were equipped with superchargers of the second type and operated for six months. In that time virtually no trouble was experienced, according to Mr. Mecklenburg, and the service requirements were also less than was the case when operating without superchargers. The car having a 4:1 rear-axle gear-ratio and a four-speed transmission showed the best over-all performance and efficiency, the slow-speed hill-climbing and high-speed performance being better than was expected. The other cars were equipped with a 4.75:1 and a 4.25:1 rear-axle gear-ratio and gave equally good performance except at top speed, this being due to the difference in gear ratio.

Points Brought Out in Discussion

Answering a question regarding the clearance between the impellers and parts of the housing, Mr. Mecklenburg stated that 0.003 in. is regarded as the maximum that is permissible and that placing the pilot gears on the impellers so as to eliminate backlash is very necessary. These gears are made with an extremely wide face to prevent wear.

W. E. John, of the Buffalo Gasoline Motor Co., spoke at some length on the problem of supercharging Diesel engines and said that the chief trouble is with scavenging. If the pressure of the incoming air is increased between 4 and 5 lb., better scavenging and better volumetric efficiency result, but increasing the pressure further does not produce better results. These statements were based on the results of tests made by the Navy. He also spoke of an instance in England in which the application of a commercial type of blower increased the output of the engine 20 per cent and decreased the fuel consumption in the same proportion. A combination of a vaporizer and the supercharger would increase the power of the Diesel engine materially. The use of light oil for starting and changing to a heavy oil for running was also mentioned.

Silichrome valves, Mr. Mecklenburg said, were found to be the best for use with the carbureter between the supercharger and the engine. He attributed the better results obtained in the second system of supercharging to the fact that a cleaner, better and drier mixture was obtained. In all systems an air-cleaner was used on the carbureter to prevent dust from being carried in between the impellers and destroying the clearance. Drop-forged steel was used for the impellers and No. 12-gage aluminum for the housing.

Asked if decreasing the compression ratio from between 4 and 4.5:1 to 3.5:1 and increasing the pressure from 5 to 10 lb. would not give better results, Mr. Mecklenburg replied that doing so would generate more heat in the supercharger and cause trouble. The object of supercharging is to get a cool charge to the engine and, with a pressure of 5 lb., a gain of 42 per cent in horsepower has been realized. With a motor-coach engine operating at 2200 r.p.m., the horsepower was increased from 119 to 163 by the application of the supercharger.

Metal Bodies and Lacquer

Steel for Body Construction and Lacquer Finishes Are New England Section Subjects

MEETING in the Hotel Kenmore, Boston, Jan. 8, the New England Section members listened to talks on metal bodies and automobile finishes. George L. Kelley, of the Edward G. Budd Co., of Philadelphia, gave a paper on the making of all-metal bodies, in which he explained in some detail recent advances in the fabrication of sheet and strip steel. Russell M. Cook, of E. I. duPont de Nemours & Co., told of the development of modern pyroxylin finishes, including a newly developed finish which has elasticity enough to make it practicable on wood as well as on metal.

Manufacture of Steel Sheets

Nearly all of the steel formerly used in automobile bodies, according to Mr. Kelley, was so-called sheet steel, which is made from open-hearth steel rolled down into blooms and then into sheet bars. All sheet bars are 8 in. wide, of length equivalent to the width of the desired sheet and of thickness according to the length required. Sheet bars are hot-rolled crosswise, then pickled and annealed. After that comes cold-rolling and another annealing.

Formerly, sheets were piled high in boxes for annealing. Up to 24 hr. was required to bring the sheets to 1100 deg. fahr., and from 36 to 72 hr. to cool them again to the temperature at which the boxes could be opened.

In the normalizing process, as now used, sheets are passed individually through a furnace which is maintained at a temperature of about 1800 to 2000 deg. fahr. The speed is controlled so that the sheets reach a temperature of about 1700 to 1725 deg.; but their exposure to this temperature is for only 1 or 2 min., after which they are cooled in a cooler portion of the furnace. This process is considerably faster and less expensive than box-annealing the sheets, and it produces sheets of much finer grain.

Great mechanical development has occurred also in the rolling of strips. Billets, say 12 in. thick, are fed into a series of mills in a continuous operation, so that they emerge at a speed of about 900 ft. per min., rolled to a thickness of perhaps 0.062 in. The product is annealed before it has time to cool. Coils are welded end to end while in motion, annealed again, and pickled. This makes completed hot-rolled strips, but most of the strips used in automobile-body manufacture are further passed through a series of cold-rolling mills.

One great improvement has been the development of four-high mills, in which the actual work is done by rolls about 12 in. in diameter, backed up by an additional pair of rolls of say 30 or 40-in. diameter. The large rolls prevent deflection in the smaller rolls, thus preventing variation in gage of the strips because of roll deflection.

Among the improvements in the finished material resulting from the newer manufacturing processes, Mr. Kelley said that the present steel has more uniform ductility and greater strength and is less subject to surface defects.

Mr. Kelley also told something about tests for steel, saying that tests for elongation are most useful in indicating drawing qualities. Standard limits for composition and physical properties might seem like the easiest basis for relations between the purchaser and the supplier of sheet and strip steel, but Mr. Kelley finds it better to adopt an attitude of greater cooperation, in which each considers the problems of the other. The supplier is given a blueprint or other information regarding the job, together with a general idea of the composition and the physical properties required. If a material proves unsuitable on the first trial, additional trials are made and the supplier is given a chance to see the material tested before it is cast aside.

Mr. Kelley then outlined the development of body making as it led up to the all-steel body, as made by the Budd company. Some description of the welding processes used in manufactur-

ing this body was given in the Production Engineering department of the S.A.E. Journal for November, 1928, p. 510. The speaker illustrated this manufacture with a number of slides and motion pictures of both the manufacturing processes and the breakdown tests. One of the films showed a car descending a runway prepared so that the car would tip over at the end. After the test, the car was driven away under its own power without replacing even the battery.

Development and Use of Lacquers

Mr. Cook gave a talk on the development of lacquer finishes, in which he said that modern lacquers have taken nothing but the name from the Japanese and Chinese lacquer which was extracted from large quantities of bugs.

Lacquer, which has been used for some time as a protective coating for brass, was first tried as an automobile finish in California, where the hot sun and alkali dust made conditions very severe for varnish finishes. This lacquer was so thin that 15 or 20 coats were required to give a sufficient thickness of film. If the material was made thicker, it could not be handled. The modern pyroxylin finish, Mr. Cook said, was the result of extended research, and the goal was finally reached in work on another subject. Nitro-cotton is now made with reduced viscosity, so that much thicker coats can be applied. This has resulted in a great change in painting processes.

The great difference between pyroxylin finishes and paints of the older types is that the paints dry by both evaporation and oxidation, whereas the lacquers dry only by evaporation. Unfortunately, the oxidation of paint and varnish continues after the finish is dry, resulting in checking and cracking.

Lacquer, as used on metal automobile bodies, has not been found satisfactory for all grades of wood. A new flexible lacquer has been developed that can be used successfully on wood and on combinations of wood and steel. It does not attain maximum hardness quite as quickly as the older type, but becomes dust free in 15 min. and hard enough to handle in 30 min., and attains its maximum hardness in two or three days. It has a natural gloss, which Mr. Cook said is not quite equal to the effect of the hand-rubbed finish secured with the lacquer ordinarily used on automobiles.

Discussion followed, in which drumming and the sound of closing metal doors were considered. Mr. Kelley said that these subjects had received much study and that methods had been developed for clinching and welding steel doors which eliminate any objectionable sound. Pastes have also been developed which deaden the drumming effect, although they cannot stop mechanical vibration.

Questions were asked in regard to the use of clear lacquer. Mr. Cook said that pigmented lacquer is preferable, since the pigment stops the ultraviolet rays from the sun. Mention was made of the need of clear finish to protect the lettering on commercial cars. It appeared that the duPont company hesitates to recommend the clear finish because of a fear that enough coats will not be applied to make the finish satisfactorily durable. One double coat looks all right, but at least two double coats are needed for durability.

Power-Actuated Brakes Discussed

Southern California Section Hears Three Papers and About the California Highway Patrol

FOLLOWING an enjoyable dinner at which an orchestra furnished seductive music to the 125 members and guests present, the Southern California Section, which convened on Jan. 3 at the Los Angeles City Club, discussed the subject of brakes at its technical session. Papers were presented by Charles Horn of the Bragg-Kliesrath Corp., Long Island City, N. Y.; C. D. Stewart of the Westinghouse Air Brake Co., New York, N. Y., and Wesley Smith of the Bendix Brake Co., South Bend, Ind.

Before the papers were presented, Chairman William Fairbanks introduced E. L. Bruck, district inspector for Los Angeles County of the California Highway Patrol, who described this recent activity.

California Highway Patrol Described

E. L. Bruck said in part that this Patrol was organized Aug. 14, 1929. Its program is that, in conjunction with the civic organizations and the State Chamber of Commerce, the Patrol has a program to bring before the motorist each month which is advertised in the newspapers and over the radio from time to time. It is endeavoring, in conjunction with the safety committees, to reduce accidents in the State of California.

Mr. Bruck stated that the Patrol will appear upon the California highways Feb. 1, 1930. Its personnel will be equipped with uniforms and with white automobiles and white motorcycles. The uniforms comprise a forest-green coat of military type and light-colored trousers. The vehicles will all bear the insignia of the Patrol on the sides and will be used in Patrol duty after dark. It is the intention to use the night Patrol not alone for motor-vehicle violations but for all violations, and to give the rural sections of the State some police protection after the sheriff's offices in the different counties are closed. The Patrol stations will be connected by telegraph. At present the Patrol covers 52 counties in the State and is expected to increase greatly the police protection in the rural sections. The police captains will operate under a unified bulletin-system, so that all will operate in the same way to bring about the same conditions in all localities and eliminate the previous condition in which the different communities operated in different ways.

The Patrol is composed at present of 286 men divided into 18 districts and having 18 district inspectors in charge. When the equipment is received, 117 men will be provided in addition, and that total force of 403 men is expected to constitute an adequate force for 24-hr. service. Later, Mr. Bruck said, police schools will be opened to all peace officers who wish to attend. In the foregoing manner it is hoped to bring about uniform traffic-enforcement, and later the Patrol will establish brake-testing stations in all the communities in which headlight-testing stations are now maintained.

Power-Actuated Brakes Advocated

Mr. Horn said in part that the type of power-actuated brakes which he represents derive their power from the vacuum created in the inlet manifold, the vacuum being greatest when the throttle is closed and the engine is not called upon to deliver power for other purposes. The 27 different models of these brakes are divided into two general classes, air suspended and vacuum suspended, the latter being again divided into two models. He described the external-valve-type boosters, which consist of two parts, the vacuum cylinder and the control valve, both of which are mounted in a similar manner, the valve being incorporated in the pedal rod and the cylinder being mounted elsewhere in the chassis where the power can be exerted on the cross-shaft.

After describing several other types of booster manufactured by the company he represents, Mr. Horn remarked that the average engine produces a vacuum of about 20 in., and that on this basis the company's 6-in. cylinder develops a 280-lb. direct pull, and the 9½-in. cylinder develops 680 lb. direct. He said also that the average equalizer

travels only 1½ in. before the pedal strikes the floor board and that, therefore, it is easily imagined what great pressure would be exerted if the company's boosters were installed so as to operate to the limit of their stroke. In conclusion, he mentioned that the installation of this type of brake in connection with heavy motor-trucks and trailers has increased the payload, has increased safety, and has resulted also in a decrease in cost per ton-mile.

Air-Brake System Discussed

Mr. Stewart asked his audience to consider that the motorcoach has but one purpose, that of carrying a revenue load from point *A* to point *B*, but he said that the brakes have a two-fold purpose, first, as a safety measure, and, second, as a revenue producer. He said further that the braking system plays an important part as regards revenue because the limited speed when descending a grade is set by the ability of the brake to control the rate of speed to a degree such that the vehicle will not run away and can be brought to a stop if necessary. In bringing a vehicle from running speed to a state of rest, the brakes are the only factor, and any improvement which can be made in this phase of the cycle is a distinct gain from both the viewpoints of safety and operating economy.

Rapid deceleration can be accomplished in several ways which were described by Mr. Stewart, a common method on light vehicles being to use a soft composition fabric brake-lining having a high coefficient of friction. An alternate is a brake-lining of metal or other hard material which has a large stable friction characteristic and a much longer operating life. These materials have a lower coefficient of friction and, to gain the benefit of the increased reliability and economy involved in their use, it is necessary to have ample pressure with which to apply them. Any satisfactory method of obtaining an adequate pressure at the brake-drums must meet the condition of operating simplicity, flexibility, perfect equalization and long mileage between adjustment, and must not impose an excessive physical effort on the part of the driver when applying the brakes.

After reviewing the different air-brake devices as they exist at present in connection with power application of brakes, and considering also brake application to trailers, Mr. Stewart concluded by saying that any type of brake should brake all wheels up to the point of sliding; that the full brake-force should be realized in the shortest possible time consistent with flexibility; that it must be remembered that kinetic energy is a function of both weight and speed where the energy increases directly with the weight but increases with the square of the speed; and that, with more than one vehicle in a train, automatic operation is the only guarantee of complete safety.

Parts Connecting the Brake Pedal to the Brakes Very Important

It was brought out by Mr. Smith that braking action is affected by a number of factors exclusive of the brake mechanism. The parts connecting the brake pedal to the brake are of great importance, but, in diagnosing brake trouble, a general tendency exists to overlook this fact. The proper setting of operating levers is another contributing factor, and the correct assembly and adjustment of the axles, springs and wheels is essential; otherwise the brakes cannot perform effectively. No brake can be made to function properly in connection with loose spring-equipment or loose bearings.

Mr. Smith described the two general classes, the three-shoe and the duo-servo brakes manufactured by his company, stating also the method of making adjustments for wear and for equalization. In conclusion and with regard to brake-drums, the speaker said that the drums should not be remachined unless satisfactory brake performance cannot be secured otherwise.

In the course of the discussion, experiences with various types of brakes were cited and many questions were asked and answered as to further details of the several systems. Models of brakes were exhibited and operated, and drawings were shown. The subject of suitable brake-force distribution between front and rear wheels was also debated, and the representatives of the several types of braking system presented further arguments favorable to their respective products.

Storage Batteries Pictured

Canadian Section Has Chairman R. H. Combs Dissect Them for Its Benefit

As explained by vice-chairman A. S. McArthur, of the Toronto Transportation Commission, who presided at the Canadian Section Meeting held Jan. 17 at the Royal York Hotel, Toronto, "those little black boxes are called 'storage batteries' here but, in England, they call them 'accumulators,' possibly because they do not store or accumulate anything." Though needing no introduction, genial "Bob" Combs, president and general manager of the Prest-o-Lite Storage Battery Co. of Canada *was* introduced as the principal speaker. Photography is his hobby, and he took the attending members and guests on a reel trip through the Prest-o-Lite factory in Toronto; to the 1929 Semi-Annual Meeting at Saranac, N. Y.; and on a trip down the St. Lawrence, through old Quebec and down to the sea, the motion pictures proving both informative and entertaining.

Mr. Combs' audience also was interested in his account of one of the most terrific explosions in the history of the world, when, during the world war, the vessels Imo and Mont Blanc collided in Bedford Harbor, Halifax, and the explosion of 3000 tons of T.N.T. razed the countryside. A 2-ton anchor was hurled 5½ miles, and buried itself in rock when it struck. A 4.7-in. gun was split across and hurled the same distance. Mr. Combs showed pictures of these relics. The members and guests were so interested that they forgot to ask a single question bearing on the paper on Storage Batteries which he presented.

Mr. Combs, after alluding to the discovery of the storage-battery principle in 1861 and tracing its evolution down to 1912 when Cadillac installed the first lighting and heating unit, went on to say that a tremendous amount of interest has developed in the storage-battery business in the last several years. In the last 10 years, the income of storage-battery manufacturers has decreased fourfold, comparing the prices paid for equipment then and now.

Three or four years ago, said the speaker, practically all storage-battery production was by hand; now, many mechanical processes enter into the business, and give better results. In the days when the oxide was pushed into the grids by hand, the work done in the morning, when the workman had a good breakfast under his belt, probably was better than the work done around 4:00 p. m. when the man was not feeling so energetic; all the plates were put into the developing tub together and the battery was only as strong as its weakest plate. Mr. Combs stressed that, even with the use of mechanical appliances, every completed battery had little individual characteristics of its own. Control of materials, particularly the oxide, was very difficult and needed constant checking.

Modern Storage Batteries Perform Heavy Duty

Proceeding, Mr. Combs emphasized what great demands are made on batteries today, especially in zero weather

when some engines require 350 amp. to break away and 250 amp. to spin. He said he had seen some four-cylinder engines take 300 amp. to spin, although they were working on a 100-amp. battery.

The battery used today on small cars, on S.A.E. rating is supposed to give a 100-amp. discharge for 20 min., and 98 per cent of batteries would do this. Some might give a 22, 23 or 24-min. discharge, although made of the same identical paste and manufactured at the same time.

In recent years many additions have been made to storage-battery usage, and instances were mentioned of the cars equipped with inside lights at each corner, headlights, side lights, ditch light, parking light and three tail-lights. The "little black box" was supposed to look after them all!

In conclusion, the speaker devoted some attention to the two great destroying elements in storage batteries; namely, sulphation, and the burning out of the battery by the generator. He also explained in detail how storage-battery plates become buckled and ruined.

Northern California Enjoys Variety

Reflectors, Governors, Carbureters and Bearings Discussed at January Meeting

THREE-RING circuses have long been known to the general public, but it remained for the Northern California Section to "out-Barnum Barnum" and put on a four-part affair at its meeting on Jan. 9 at the Engineers Club in San Francisco. Chairman H. L. Hirschler presided, and the four artists who performed were Sam L. Boukard, secretary, treasurer and director of the American Woodlite Corp., who discussed the Application of New Reflector-Contours to Modern Automotive Lighting Equipment; L. H. Laufer, of Lathan & Co., Inc., who spoke briefly on Governing Engines To Reduce Operating Costs; C. A. Christensen, also of Lathan & Co., whose topic was Efficient Carburetion; and George H. West, who presented a paper on Copper-Lead Bearings written by Robert D. Pike, vice-president and general manager of the Kalif Corp.

Light Distribution with New Reflector

In the first paper of the evening, Mr. Boukard described the latest type of head-lamp reflector developed by his organization, in which the general reflecting contour is substantially elliptical on both converging horizontal and vertical planes and is continuous, without steps. The form of reflecting surface used was the result of an effort to eliminate glare. Correct distribution is secured by projecting a flat-top beam on the horizontal plane at a height parallel to the top of the aperture, which is in line with the filament, providing a wide lateral spread, 82½ deg. on each side of the axis of the vehicle, and a deflection of approximately 3¼ deg. downward on each side of the center 4 deg. of lateral spread. Using a narrow aperture through which the light is emitted renders approximately 10 sq. in. of reflecting surface visible to the approaching driver as compared with 123 sq. in. in a parabolic-reflector lamp with a 7-in. lens.

More than 90 per cent of the spherical candlepower is utilized in projection as compared with from 48 to 63 per cent in other types of head-lamp, according to Mr. Boukard, who said also that eye fatigue is eliminated by the absence of contrasts, and sufficient visibility for average speed in fog, rain and sleet is secured by controlling the beam and projecting all light below the eye level of the operator, thus preventing any reflection back into his eyes. The necessity for auxiliary lamps is eliminated owing to the area of the driving field covered.

The reflecting contour has a relatively simple upper section, being a truncated hemi-ellipsoid of revolution, while the lower surface is formed of a combination of all the conic sections.

Following the presentation of the paper, Mr. Boukard took apart one of the head-lamps and described the interior construction in detail.

Examples of Engine-Governor Advantages

Controlling engine-speed, said Mr. Laufer, the second speaker, protects an investment ranging from $700 to $10,000 and in some cases $15,000. The cost of speed is determined by the wear and tear on the equipment, such as the wristpins, bearings and crankshafts of the engine, the transmission and the tires. Among the instances cited of this were a case in which a fleet operator found that, after governing his trucks, he secured 35 per cent more tire mileage because no more violent applications of the brakes occurred, and another case in which a $25,000 damage suit was thrown out of court because a fleet operator was able to prove that his vehicle could not travel at an excessive rate of speed.

Easy-Servicing Carbureter Features

C. A. Christensen, who spoke next, described the latest model of the Zenith carbureter, in which a regulating jet is used for lean mixtures through the main jet and an accelerating pump is provided to aid in picking up heavy loads. Other features are a unit construction of the needle-valve and its seat so that replacement is merely a matter of unscrewing one assembly and putting in another. As these are interchangeable, no adjustment is required. The filter screen can be removed without disconnecting the gasoline line, which is another change from the earlier design.

Mr. Pike's paper described some of the properties of bearings made from a mixture of approximately 75 per cent of copper and 25 per cent of lead. While this alloy has been known for many years, its use has been somewhat limited because of difficulties experienced in casting it. Special methods have been developed for casting the copper-lead mixture in stationary molds, which ensures freedom from porosity and lead segregation and also enables copper-lead castings to be reinforced with stronger metals.

Copper-Lead Bearing Applications

One application of the bearings is to automotive engines, in which they are installed in the crankcase in the usual way except that they are compressed approximately 0.008 or 0.010 in. and then line-bored, this procedure giving a perfect seat in the engine frame, according to the author. Installation of these bearings in a motor-coach engine has given upward of 100,000 miles of service in intercity operation without adjustment, it was stated.

Bearings of a larger size are centrifugally cast into a basket or cage of Admiralty bronze, which gives great structural strength. This type of bearing is recommended for Diesel engines, side-rod bearings for steam locomotives and similar uses. Because of their high heat-conductivity and relative infusibility, these bearings also find extensive application in electrical machinery of all kinds. Solid bushings are recommended by the speaker for small motors; for larger industrial and traction motors, a centrifugally cast copper-lead liner is sweated inside of a bronze or cast-iron shell. Other applications of these bearings are to railroad-car and locomotive-tender journals and as roll-neck bearings in steel plants. These are made by casting the alloy under special conditions into a framed backing of Admiralty bronze of peculiar design.

Oregon Section Organized

Portland Members Unite To Form a New Section and Fraternize at Dinner

AT THE first meeting of the Oregon Section, held Jan. 10 in the grand ballroom of the Multnomah Hotel, Portland, Ore., 60 members and guests assembled at the dinner and an additional number attended the technical session. Orchestral music was furnished through the courtesy of the C. W. S. Grinding & Machine Works, an additional feature being a display of automobile parts at one end of the ballroom. These parts were furnished by representatives of the Packard, Franklin, and Chrysler cars, and by the local Polytechnic School. Both before and after the meeting, these exhibits attracted considerable attention, as did also the display in the lobby of the hotel from Jan. 9 to 11 of a Packard sedan, representing water-cooled cars; a Franklin sedan, representing air-cooled cars; and a Cord car, as a representative of front-wheel-drive cars. These cars were labeled as Oregon Section exhibits, thus informing the public of the formation of the new S.A.E. Section in Portland.

Because Chairman A. R. Trombley was snowbound in Idaho, H. W. Drake, Vice-Chairman, presided. In opening the meeting, Mr. Drake expressed the appreciation of the Oregon Section to those who had furthered the success of this meeting by providing the exhibits and engaging actively in the work of making the arrangements. He called for a reading of the minutes of the last two meetings held in Seattle with the Northwest Section, which explained the reasons for forming the new Section in Portland, and also read a telegram of approval from S.A.E. headquarters.

Technical Session Proves Interesting

Various speakers gave short talks, among them being W. R. Jones, formerly project engineer for the Boeing Airplane Co., of Seattle; Lee W. Oldfield, formerly Secretary of the Chicago Section; and Tex Rankin, well-known local aviator, who has made 19 successful outside loops with an airplane. The recently elected officers of the Section were introduced by Rolla Moore, Portland manager of the White Co.

G. P. Texada, automotive engineer of the Standard Oil Co. of California, presented a paper on Lubrication, accompanied by lantern slides showing laboratory equipment and manufacturing processes generally used. This elicited a lively and rather long discussion. Prof. Fred G. Baender, head of the department of mechanical engineering of the Oregon State College, presented lantern slides relating to Diesel engines and made comments upon them.

Regarding the February meeting, communication with Prof. S. H. Graf, of the Oregon State College, resulted in his agreement to present a paper entitled, Automotive Steels and the Fundamentals of Their Heat-Treatment. He states that the paper will be fully illustrated with lantern slides and that he will bring specimens and a microscope by which they may be examined by those who so desire. He may also bring a metallograph by which means the structure of a specimen can be projected upon the screen.

An entertainment feature undoubtedly will be scheduled, this being Don DeForest's orchestra, a well-known local broadcasting organization.

University of Detroit Student Branch Meeting

AT THE first meeting of the current year of the University of Detroit Student Branch of the Society, which was held on the evening of Dec. 12, the Branch showed its appreciation of the help and guidance given it by Prof. F. J. Linsenmeyer by electing him Honorary Chairman. Alfred Havas was elected Chairman to succeed Otis Taylor; Herbert Kosel was elected Vice-Chairman, and George Miller was elected to serve as both Recording and Corresponding Secretary. Manuel Simms was elected to act as Treasurer.

The first speaker of the evening was F. C. Hecox, of the Cadillac Motor Car Co., and Chairman of the Society's Student Branch Committee. He spoke of the increasing interest the Society is taking in Student Members and explained at length the many advantages offered to such members by the activities of the Society. Under a new recommendation of the Committee, which will require amendment of the Constitution before it can become effective, a student of a recognized institution of engineering or pursuing a course of study in aeronautic engineering, may, if under 30 years of age, join the Society for the duration of his college course plus one year thereafter.

Motion pictures of the processes in the forging, heat-treating and gear-cutting departments of the Timken-Detroit Axle Co. were exhibited by Mr. Flynn, of the Timken Company, who answered a volley of questions from the student members on various phases of the work that had been shown.

Where Light and Heavy Meet

Dayton Flocks to Joint Meeting with Mechanical Engineers To Hear about Buoyant Aircraft

WITH 40 persons present at the dinner and 250 at the technical session, the joint meeting of the Dayton Sections of the S.A.E. and the American Society of Mechanical Engineers, which was held on the evening of Jan. 7 at the Engineers' Club, was much the largest ever held or participated in by the Dayton Section.

The attractions that accounted for the unusual attendance were an address on the Zeppelin, given by V. R. Jacobs, assistant manager of the aeronautics department of the Goodyear Tire & Rubber Co., and motion pictures of airships in flight. Captain Eckener and his guests were shown enjoying a trip in the Graf Zeppelin, and the ability of pilots to maneuver semi-rigid airships was shown in pictures of their landings on hotel and apartment-house roofs.

Talking of the importance of airplanes to a Dayton audience was somewhat in the nature of carrying coals to Newcastle, but Mr. Jacobs devoted the introductory part of his address to heavier-than-air craft, in the belief that the people there regard aircraft in terms of military service rather than in terms of the tremendous part that airplanes take in the economic, commercial and social activities of the times. No other nation has so many airplanes, mail lines and transport lines as the United States, asserted Mr. Jacobs.

Turning to his real subject, Mr. Jacobs said that the non-rigid and semi-rigid airships are not fitted with gas cells, the gas being contained directly in the envelope. Accordingly, the range of size is equally restricted. The two types are identical except for a metal keel reaching from end to end of the semi-rigid, which usually has about 750,000-cu. ft. capacity. The only semi-rigid in this Country is the RS-1, of the United States Army.

Count Zeppelin is said to have obtained his idea for the rigid airship in the United States and to have drawn his plans before returning to Germany. So this type is not entirely of German origin, and securing proper recognition for it in Germany was difficult.

Following these statements, Mr. Jacobs indicated the progress in rigid

airships by giving the sizes of several: the Los Angeles, 466,000 cu. ft. and 660 ft. long; the Graf Zeppelin, 3,710,000 cu. ft.; the R-100, originally 5,000,000 cu. ft. and 725 ft. long, being increased to 5,500,000 cu. ft. and 800 ft. long; and the two craft now under construction for the United States Navy, which will contain 6,500,000 cu. ft. each. Some of the details of these craft were described, also details of the enormous hangar that is being built for them in Akron, Ohio.

A great future is visualized for the lighter-than-air craft in the promotion of world peace and understanding.

Oil Refining Discussed

DR. WINSLOW H. HERSCHEL, physicist of the United States Bureau of Standards, presented a paper on the refining of motor oil before an audience of 175 members and guests of the Pittsburgh Section, who at the meeting held gathered on Jan. 28 in the auditorium of the Pittsburgh Chamber of Commerce.

The results of the election of officers of the Section was announced. Nils G. Bjorck was elected Chairman; H. V. Thaden, Vice-Chairman; B. H. Eaton, Secretary; and C. R. Noll, Treasurer.

February Aeronautic Meeting

(*Concluded from page* 274)

lock, which has been responsible for a number of deaths of pilots. He will explain its action and suggest means for its elimination. Vapor lock is the interruption of gasoline flow by bubbles of gas or vapor formed in the fuel-feed system. While merely a cause of annoyance to the motorist who is safely on the ground, it constitutes a source of danger to the occupant of an airplane. Therefore a description of Dr. Bridgeman's work at the Bureau of Standards and his suggestions for the elimination of this troublesome condition will be of great interest to all pilots and those using the air for transportation. A further paper on radio will be presented by E. A. Robertson and Dr. L. N. Hull, of the Radio Frequency Laboratories.

William B. Robertson, of the Curtiss-Robertson Airplane Mfg. Co., will discuss airplane production methods; E. L. Nelson and F. M. Ryan, of the Bell Telephone Laboratories, will contribute a paper on the provision of radio facilities for aircraft communication. There will also be an interesting résumé of what has been learned about fog flying by Lieut. James Doolittle. Lieutenant Doolittle's recent flight in a specially equipped machine, curtained so that he was unable to see but was required to fly entirely by instruments, will be described in detail, and his predictions will be listened to with a great deal of interest because he can speak authoritatively on this subject.

Fuels, Instruments and Engines

Fuels will also come in for their share of discussion, a paper on the gasoline requirements of commercial-aircraft engines being contributed by H. K. Cummings, of the Bureau of Standards.

Other papers will be contributed by J. B. Peterson of the Bureau of Standards, and E. W. Rounds, of the Bureau of Aeronautics, on flight-test instruments. Roland Chilton, of the Wright Aeronautical Corp., will discuss ways and means in aircraft powerplant development to meet operators' demands. The relation between automobile and aircraft-engine design will be contrasted by Robert Insley, of the Continental Aircraft Co.; and William F. Wise, of the Ex-Cell-O Aircraft & Tool Corp., will set forth his conception of production methods of aircraft tools.

The only social event planned is a dinner to be held jointly with the Aeronautical Chamber of Commerce. K. M. Lane, of the Department of Commerce, will be the only speaker. The title of his address will be The Defects of Modern Aircraft. Chance M. Vought will be toastmaster.

Leonard C. Baldwin

WITH much regret the untimely death of Leonard C. Baldwin, of Bayonne, N. J., in an automobile accident on Nov. 26 is recorded.

Although but 31 years of age, having been born in New York State in 1898, Mr. Baldwin had been identified for 15 years with the automotive industry, for a large part of the time as a layout and designing draftsman but since 1924 in sales engineering work.

After taking the mechanical engineering course at Pratt Institute in Brooklyn, N. Y., from 1915 to 1917, Mr. Baldwin served as detailer and tracer for Gould & Eberhardt, in Newark, N. J.; inspector of Hispaño-Suiza engine parts for the Wright-Martin Aircraft Corp., in New Brunswick, N. J.; detailer and tracer on the King-Bugatti aviation engine for the Duesenberg Motors Corp., in Elizabeth, N. J.; layout man and checker on Caproni and Handley Page airplanes for the Standard Aircraft Corp., of Elizabeth; motor-truck layout draftsman for the H. J. Koehler Motor Corp., of Newark, N. J.; ball-bearing installation engineer for the S K F Industries, of New York City; and designing draftsman for the International Motor Co., of New York City.

In 1925, the third year of his connection with the last-named company, Mr. Baldwin was appointed assistant to the manager of the sales-engineering department and the following year was made assistant to the special-equipment engineer. After holding this position with the International Motor Co. for three years, he transferred his services last year to the Standard Oil Co. of New Jersey, for which he was acting as a sales engineer at the time of his fatal accident.

Mr. Baldwin was elected to the grade of Junior member in the Society in March, 1919, and was transferred to Associate grade in 1928.

Theodor Kollinek

WORD has been received here of the death of Theodor Kollinek, diploma engineer, chief engineer of Knorr-Bremse A. G., of Berlin, Germany, on Dec. 13.

Mr. Kollinek's education was acquired in Brünn, where he was born in 1889, and where he studied at the Technische Hochschule, receiving Second State Probation, which enabled him to become a Diploma Engineer. He received his diploma in engineering from the Technische Hochschule in November, 1912, from the Charlottenburgh Technische Hochschule in Berlin, and became a prolific contributor to the various automotive technical and trade papers of Germany and Austria, some of these being *Der Motorwagen, Autotechnik, Allgemeine Automobilzeitung, Deutsche Motorzeitschrift, Verkehrstechnik, Moderner Motorrad und Autosport, Luft und Kraftfahrt, Automobil Motorrad und Flugwesen.*

Soon after receiving his diploma in engineering, Mr. Kollinek was employed in 1912 as a constructor in the general building of machines for the firm of Brandt & Luhilier, of Brünn. He joined the Austrian Navy as a naval engineer the following year and held this post until 1916, when he assumed a similar position as submarine constructor with the Stabilimento Tecnico, of Trieste. In 1919 he became a director of the firm of Hassman & Sohn, in Schonwalde, engaged in the general building of machines. He joined the Knorr-Bremse A. G. as chief constructor in 1920, and at the time of his death was chief engineer with that company.

Mr. Kollinek was elected a Foreign Member of the Society in March, 1928. He was also a director of the Automobil und Flugtechnische Gesellschaft, of Berlin, which is the automobile and aeronautic technical society of Germany.

Stewart H. Hartshorn

WORD has been received of the death, on Dec. 14, 1929, of Stewart H. Hartshorn, vice-president of the Stewart Hartshorn Co., of East Newark, N. J.

Mr. Hartshorn was born in April, 1876, at Short Hills, N. J. He was a graduate of Harvard University, receiving the degree of Bachelor of Arts in 1898.

From 1900 on he designed and built special machinery and was particularly known as the designer of the Hartshorn universal strap-end adapted to aeroplane work, which he completed in 1918.

Mr. Hartshorn became a Member of the Society in 1919, being at that time vice-president of the Stewart Hartshorn Co., of New York City. In 1922 the company's offices and plant were removed to East Newark. In 1926 Mr. Hartshorn became a member of the Metropolitan Section of the Society.

Personal Notes of the Members

Thomas Now Peerless Chief Engineer

The post of chief engineer of the Peerless Motor Car Corp., of Cleveland, has been accepted by S. R. Thomas, who for more than 10 years was connected with the Jordan Motor Car Co. of the same city, the last two in the capacity of chief engineer.

Mr. Thomas combines a thorough knowledge of engineering theory and extended practical automotive experience. Following his graduation from the University of Michigan in February, 1913, he remained at the institution for two years as a member of the faculty, first as assistant to Prof. J. E. Emswiler, of the mechanical engineering department, and later as instructor in the automobile engineering department.

Early in 1915 Mr. Thomas became experimental engineer for the Hudson Motor Car Co., of Detroit, and two years later was promoted to the post of assistant to the chief engineer. During 1919 he served as assistant to the chief engineer of the Central Division of the General Motors Corp. In 1920 he accepted a corresponding position with the Jordan Company, and two years ago was appointed chief engineer.

Mr. Thomas was elected a Member of the Society in May, 1915. He is a life member of the University of Michigan Union and a perpetual member of the Cleveland Club.

England Leaves Stearns-Knight

William Ernest England, who for the last nine and a half years was chief engineer of the F. B. Stearns Co., of Cleveland, has severed his connection with that firm. His plans for the future have not been announced.

Mr. England is a graduate of the Mechanical Engineering School of Drexel Institute, of Philadelphia, and has been identified with the automobile industry for more than 19 years. His first position was that of machinist with the Spicer Mfg. Co., of Plainfield, N. J., which he held for one and one-half years. In 1911 he was a machinist and draftsman for the Worth Motor Car Co., of Kankakee, Ill., and in 1912 accepted the position of chief draftsman of the Service Motor Truck Co., of Wabash, Ind. After working nearly a year for the Midland Motor Co., of East Moline, Ill., he effected a connection in 1913 with the Moline Automobile Co., the Root & Van Dervoort Engine Co. and the R & V Motor Co. The last three closely connected companies built the Moline-Knight and R & V Knight cars, Knight sleeve-valve engines and poppet-valve engines for the trade.

During the last two years of this connection, which continued until 1920, Mr. England was chief engineer and had complete charge of all designing and experimental work and of the pattern shop. In May of that year he accepted the post of chief engineer for the Stearns Company, a pioneer in the industry and builder of the Stearns-Knight passenger automobiles. In this position Mr. England had charge of all design, pattern, experimental and inspection work and helped to develop many refinements in the product.

WILLIAM E. ENGLAND

In January, 1919, Mr. England was elected to Member grade in the Society, and two years later joined the Cleveland Section. During 1924 he served on the Transmission Division of the Standards Committee. At present Mr. England is Chairman of the Cleveland Section.

Sweet Changes His Connection

Announcement has been received that H. W. Sweet has left the Chrysler Corp. to become chief engineer of the Krohn Differential Corp., of Buchanan, Mich.

After being graduated from Syracuse University with the degree of mechanical engineer in 1906, Mr. Sweet started work with C. E. Lipe, of Syracuse, as transmission and tool designer. Four years later he formed a connection with the Brown-Lipe Gear Co., of Syracuse N. Y., as chief engineer, and remained with that company until 1928. He then accepted a position with the Fuller & Sons Mfg. Co., as engineer. In 1929 he became a special designing engineer with the Chrysler Corp. in Detroit.

Since September, 1917, Mr. Sweet has been a Member of the Society, and, beginning with the year 1924, has served on the Transmission Division of the Standards Committee.

Lee Oldfield Connects with Merz

Lee Oldfield, who has been engaged in the consulting engineering field on his own account for some time, is serving the Merz Engineering Co., of Indianapolis, as a consultant and has his headquarters in that company's offices.

Subsequent to working three years as mechanic and chauffeur, Mr. Oldfield was engaged by the Los Angeles Motor Car Co.'s sales and service department in August, 1908, and remained with that company until April, 1910, when he took a position with the E-M-F Co., of Detroit, in the experimental department. Thereafter he devoted himself to experimental and sales work, serving successively the American Simplex Co., of Mishawaka, Ind.; the Matheson Automobile Co., of Wilkes-Barre, Pa.; the Nordyke & Marmon Co., of Indianapolis; and the Ray Harroun Co., also of Indianapolis. After being engineer for the Aerial Motors Corp., of Minneapolis, from May, 1915, until November, 1917, he became a captain in the United States Air Service, with which he remained until 1920.

In July of that year, Mr. Oldfield became engineer for the Frankford Motors Co., of Philadelphia, and subsequently engaged in experimental and research work for the Motor Efficiency Co., of Indianapolis, and the Northern Motors Co., of Chicago, working out designs and experimental development of the Pak-Age-Kar for the latter. When the Package Car Corp., of Chicago, was organized, he was engaged as consulting engineer, which post he held until last year, when he became consulting engineer of several Mid-Western companies.

Elected to Membership in the Society in 1913, Mr. Oldfield was transferred from Associate to Member

(*Continued on p.* 44)

Applicants Qualified

The following applicants have qualified for admission to the Society between Dec. 10, 1929, and Jan. 10, 1930. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

ARMSTRONG, THOMAS W. (A) sales manager, Fiske Bros. Refining Co., 24 State Street, New York City; (mail) 7-235 General Motors Building, *Detroit.*

ATZBERGER, FRANK X. (A) 126 Paulison Avenue, *Ridgefield Park, N. J.*

BAIRD, JOHN N. (A) general manager, Utility Trailer Sales Co., 1242 Mission Street, *San Francisco.*

BARLOUGH, STEPHEN L. (A) designing engineer, special research department, Chrysler Corp., *Detroit.*

BAUGHMAN, WILLIAM F. (A) foreman, Rosie's Sales & Service Corp., *New Rochelle, N. Y.;* (mail) 47 Howard Parkway.

BLANC, FERNANDO (A) manager, F. Blanc & Co., Turin, Italy; (mail) Post Office Box 495, *Turin, Italy.*

BOECK, EDWIN J. (A) secretary, treasurer, Truck Equipment Co., Inc., 1791 Fillmore Avenue, *Buffalo.*

BRONSON, BUDD (A) secretary, chief engineer, Ohio Rubber Co., *Cleveland.*

BROOKS, ROY OAKLAND (A) manager, Northern California branches, Standard Safety Corp., 1425 West Pico Street, Los Angeles; (mail) 1544 Pine Street, *San Francisco.*

CAMPBELL, MARK M. (M) Kinner Airplane & Motor Corp., 635 West Colorado Boulevard, *Glendale, Calif.*

CHAMBERLIN, CLARENCE D. (M) president, Crescent Aircraft Corp., 1819 Broadway, *New York City;* (mail) Hotel Biltmore.

CLARKE, NOEL LANGTON (A) assistant manager, truck delivery division, T. Eaton Co., Ltd., 190 Yonge Street, *Toronto, Ont., Canada;* (mail) 15 Scarboro Road.

CLARKE, ROBERT HUNTLEY (S M) assistant mechanical engineer, power plant branch, Air Corps, Wright Field, *Dayton, Ohio.*

COLE, JOHN S. (J) automotive engineer, The Texas Co., Norfolk, Va.; (mail) Hotel Roanoke, *Roanoke, Va.*

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EMERSON, GILBERT G. (M) chief airplane engineer, Wright Aeronautical Corp., *Paterson, N. J.*

FAIRFIELD, WILLIAM A. (A) special representative, national sales division, International Harvester Co. of America, 200 Potrero Avenue, *San Francisco.*

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HANSHUE, HARRIS M. (A) president, general manager, Western Air Express, Inc., 117 West Ninth Street, *Los Angeles.*

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HODSDON, C. H. (A) head machinist, Nelson Motor Co., *Spokane, Wash.;* (mail) 633 West Providence Avenue.

HODSDON, GENE F. (A) service salesman, Wells Chevrolet Co., *Spokane, Wash.;* (mail) 633 West Providence Avenue.

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INDUSTRIAL ALCOHOL INSTITUTE, INC. (Aff.) 420 Lexington Avenue, *New York City;* Representative: Ferris, Le Roy, assistant secretary.

JAMES, FREDERICK ERNEST (A) manager, French Motor Car Co., Ltd., New Queens' Road, *Bombay, India.*

KELLEY, WILLIAM HAROLD (A) production manager, Brewster & Co., Queensboro Plaza, Long Island City, N. Y.; (mail) 36 California Avenue, Chester Park, *Hempstead, L. I., N. Y.*

KERBER, LAWRENCE V. (M) president, Spartan Aircraft Co., *Tulsa, Okla.*

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LEGROS, LAWRENCE S. (J) draftsman, Scripps Motor Co., 5817 Lincoln Avenue, *Detroit;* (mail) 7383 Churchill.

LONG, ROBERT B. (A) service manager, Wells Chevrolet Co., First Avenue at Adams, *Spokane, Wash.*

MCGARRY, FREDERICK J. (A) partner, Crescent Machine Works, 821 Monroe Street, North, *Spokane, Wash.;* (mail) 1415 Third Avenue.

MCGILLIVRAY, JAMES MALCOLM (A) branch manager, Mack Trucks of Canada, Ltd., 1941 Yonge Street, *Toronto, Ont., Canada.*

MEHL, BERNHARD MARTIN (M) assistant engineer, Oliver Farm Equipment Co., *Battle Creek, Mich.;* (mail) 607 Maple Street.

MORGAN, D. W. R. (M) manager, internal-combustion engineering, Westinghouse Electric & Mfg. Co., South Philadelphia, Pa.; (mail) Post Office Box 1522, *Philadelphia.*

MOSSOP, ADELBERT (A) automobile mechanic, Klinger Brothers, 1696 Jerome Avenue, New York City; (mail) 647 Central Avenue, *Brooklyn, N. Y.*

NOFZ, HAROLD (J) tool and die designer, Bowen Products Co., 2760 West Warren, *Detroit;* (mail) 12353 Wisconsin Avenue.

NOLL, CHARLES R. (M) automotive lubrication engineer, Gulf Refining Co., 1157 Frick Building Annex, *Pittsburgh.*

NOYES, EDWARD E. (J) 311 Sterling Place, *Brooklyn, N. Y.*

PALMER, SEYMOUR CARLOS (A) training commercial-car sales engineers, General Motors Export Co., General Motors Building, *New York City.*

PIERLE, HENRY C. (A) secretary, sales manager, R. K. LeBlond Machine Tool Co., *Cincinnati.*

PREBLE, NORMAN H. (M) vice-president, chief engineer, Mechanical Handling Systems, Inc., *Detroit;* (mail) 3454 Denton Avenue.

PUFFER, SAMUEL R. (M) mechanical engineer, River Works, General Electric Co., *Lynn, Mass.*

RAWDON, HERB (M) chief engineer, Travel Air Co., *Wichita, Kan.*

RICART, W. P. (F M) director, chief engineer, Automobiles Ricart-España, San Andres, *Barcelona, Spain;* (mail) 7 Ronda San Pedro.

ROWAT, GEOFFREY H. (M) sales engineer, Canadian S K F Co., Ltd., *Toronto, Ont., Canada;* (mail) 1057 Bay Street.

RUSSEL, EUGENE R. (M) general foreman, mechanical department, Atlantic Refining Co., Philadelphia; (mail) 49 Elberon Avenue, *Lansdowne, Pa.*

RYAN, JOHN T. (A) sales engineer, Mack International Motor Truck Co., 25 Broadway, New York City; (mail) 195-208 37th Avenue, *Flushing, L. I., N. Y.*

RYDBERG, JOHN T. (A) supervisor, maintenance, player and reproducing pianos, Hahne & Co., Newark, N. J.; (mail) 338 Hamilton St., *Harrison, N. J.*

SAYERS, W. G. (M) factory superintendent, Willys-Overland, Ltd., West Toronto, Ont., Canada; (mail) 37 Cuthbert Crescent, *Toronto, Ont., Canada.*

SCHOLL, L. R. (A) service manager, Sterling Motor Co. of California, 1190 Howard Street, *San Francisco.*

SCHULTE, WALTER B. (M) secretary, chief engineer, Burgess Battery Co., *Madison, Wis.*

SHOWALTER, VICTOR E. (M) chief engineer, aircraft instrument division, Elgin National Watch Co., *Elgin, Ill.*

TARAKAJIAN, HARRY (J) apparatus development laboratory, Bell Telephone Laboratories, 463 West Street, New York City; (mail) 528 Eighth Street, *Brooklyn, N. Y.*

THULIN, BJARNE (M) project engineer, powerplant section, General Motors Research Corp. Laboratories, General Motors Building, *Detroit.*

TREES, L. W. (A) sales and service engineer, Scintilla Magneto Co., Inc., *Sidney, N. Y.*

VAN RIPER, JURIAN WARD (J) student, Stevens Institute of Technology, Hoboken, N. J.; (mail) 117 Lafayette Avenue, *Passaic, N. J.*

WEISS, JOHN E. (J) Wright Aeronautical Corp., Paterson, N. J.; (mail) 105 Lakeside Drive, *Nutley, N. J.*

WILLCOX, EDWARD C. (J) salesman, Curtiss Flying Service, *New York City;* (mail) 200 East 63rd Street.

WILLIAMS, PERCY S. (A) general manager, Hall-Scott Motor Car Co., Seventh Street and Heinz Avenue, *Berkeley, Calif;* (mail) 6 Vallejo Street.

Applicants for Membership

The applications for membership received between Dec. 15, 1929, and Jan. 15, 1930, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ADAMS, CHARLES G., manager and partner, Twin City Die Casting Co., *Minneapolis.*

ALLDREDGE, MARSHALL H., JR., salesman, Thompson Products, Inc., *Detroit.*

ANDERSON, CLAY, commercial-car and truck representative, Dodge Bros. Corp., *New York City.*

ANDREWS, GEORGE S., director of control-instruments division, Guaranty Trust Co., *New York City.*

BANKS, K. C., sales representative, American Car & Foundry Motors Co., *New York City.*

BAUDOIN, LOUIS A., assistant supervising engineer, Sinclair Refining Co., *New York City.*

BELLIS, ALFRED P. S., chief electrical engineer, John A. Roebling's Sons Co., *Trenton, N. J.*

BERKY, RADFORD J., draftsman, Curtiss Aeroplane & Motor Co., *Garden City, N. Y.*

BLACKSTOCK, GIBBS, 1106 Star Building, 80 King Street West, *Toronto, Ont., Canada.*

BOLTON, J. V., lubrication engineer, Cities Service Oil Co., *Kansas City, Mo.*

BORELL, ELMER A., motive power engineer, Reading Co., *Reading, Pa.*

BOULTBEE, H. N., secretary, treasurer and managing director, Boultbee, Ltd., *Vancouver, B. C., Canada.*

BROOKER, CHARLES NEWALL, technical section head, service department, General Motors Near East S/A, *Alexandria, Egypt.*

BROWN, GIBSON W., superintendent of motor-vehicles, Bell Telephone Co. of Pennsylvania, *Pittsburgh.*

BRUNNER, ALBERT, automotive research, Wagner Electric Corp., *St. Louis.*

BURNHAM, W. E., assistant chief engineer, Travel Air Co., *Wichita, Kan.*

BUSCHMANN, HEINRICH, professor, diploma engineering, Staatl. Hon. Maschinenbauschule Esslingen, *Esslingen, Germany.*

CAMM, JOSEPH RAYMOND, branch sales manager, Detroit office, National Tool Co., *Cleveland.*

COSGROVE, JOSEPH M., superintendent, Noblitt Sparks Industries, *Columbus, Ind.*

COZZOLI, MICHELE, assistant designer, Curtiss Aeroplane & Motor Co., Inc., *Garden City, N. Y.*

CROSET, LOUIS PAUL, engineer, designer in charge of experimental department, Aveling & Porter, Ltd., *Rochester, England.*

CULVER, EDWIN E., service manager, Furlong Auto Co., *Denver.*

DAVIDSON, COLEMAN LAWSON, engineer, Ethyl Gasoline Corp., *New York City.*

DAVIES, J. MILTON, research engineer, Caterpillar Tractor Co., *San Leandro, Calif.*

DENNINGER, ELBERT, student engineer, Mack Bros. Motor Car Co., *Allentown, Pa.*

DIEDERICHS, W. J., metallurgist, The Autocar Co., *Ardmore, Pa.*

DUNNELL, WILLIAM WANTON, JR., experimental engineer, bushings department, Merriman Bros., Inc., *Boston.*

ELFNER, H. L., field engineer, International Harvester Co., *Chicago.*

ESHBAUGH, JESSE E., research and experimental engineer, A. C. Spark Plug Co., *Flint, Mich.*

FIGENTZER, ERWIN THEODORE, parts clerk and chauffeur, Bates Chevrolet Co., Inc., *New York City.*

GILBERT, WARREN VAN R., sales engineer, Aluminum Co. of America, *Detroit.*

GILLIES, HUGH A., sales manager, American Brake Materials Corp., *Detroit.*

GLEICK, JOSEPH THEODORE, chief, production engineering department, Curtiss-Robertson Airplane Mfg. Co., *Robertson, Mo.*

GOETZ, PAUL F., mechanical draftsman, Foote Bros. Gear & Machine Co., *Chicago.*

HAYWORTH, BYRON B., draftsman, Moreland Motor Truck Co., *Burbank, Calif.*

HIGGINBOTHAM, ROBERT RAY, project engineer, Stearman Aircraft Co., *Wichita, Kan.*

HILT, JOHN J., sales manager, Young Radiator Co., *Racine, Wis.*

HOPKINS, GEORGE HAROLD, chief engineer, Vortox Mfg. Co., *Claremont, Calif.*

HUCKLE, MYRON S., research assistant, Massachusetts Institute of Technology, *Cambridge, Mass.*

HUTCHENRUETHER, LOUIS, supervisor of quality, Federal Mogul Corp., *Detroit.*

HUTCHISON, MILLER REESE, JR., Hughes Building, *South Orange, N. J.*

ISTAD, LARS J., designer, Fairchild Engine Corp., *Farmingdale, N. Y.*

KENNEDY, LIEUT. JOHN P., Field Artillery, *Schofield Barracks, T. H.*

LAMBERGER, EDWARD H., engineer, railway division, Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.*

LERCH, G. PALMER, mechanical supervisor, Reading Co., *Reading, Pa.*

LESSELLS, JOHN M., in charge of mechanics section, research department, Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.*

LUCAS, JOSEPH, LTD., *Birmingham, England.*

MACDONALD BROTHERS, INC., *Boston.*

MARSHALL, FRED T., assistant manager, B. F. Goodrich Rubber Co., *Chicago.*

MASON, ROY B., garage superintendent, Kansas City Gas Co., *Kansas City, Mo.*

MATHIEU, JEAN LEON, toolmaker, Star Engraving Co., *Houston, Texas.*

MILES, ROBERT GEORGE, service manager, Premier Motors, Ltd., *Edmonton, Alberta, Canada.*

MORRISON, JAMES MURTAUGH, sales representative, Valvoline Oil Co., *New York City.*

MOORE, THOMAS G., assistant production manager, Federal Motor Truck Co., *Detroit.*

MOSHER, ROY ASHER, inspector parts and materials, Pioneer Instrument Co., *New York City.*

MUSSER, J. W., superintendent of plants, Aero Supply Mfg. Co., Inc., *College Point, N. Y.*

MYNARD, LEONARD MAURICE, assistant technical manager, Delco-Remy & Hyatt, Ltd., *London, England.*

ONTARIO RESEARCH FOUNDATION, *Toronto, Ont., Canada.*

PALMER, JOHN R., assistant parts and service manager, Olds Motor Works, *New York City.*

PHELPS, R. L., superintendent, Cessna Aircraft Co., *Wichita, Kan.*

PIKE, ROBERT D., vice-president and general manager, Kalif Corp., *San Francisco.*

POLO, J. B., designing, laying out, detailing, Waukesha Motor Co., *Waukesha, Wis.*

REFFANSPERGER, H. EDWARD, student, Butler University, *Indianapolis.*

RAUSCHER, MANFRED, chief engineer, Engineers' Aircraft Corp., *Stamford, Conn.*

RAY, L. G., officer, State Highway Patrol, *Olympia, Wash.*

RICE, ROBERT MACLEAN, motive-power inspector, Reading Co., *Reading, Pa.*

ROBINSON, SETH B., JR., staff assistant, The White Co., *New York City.*

ROOT, PHILIP W., general manager, Point Spring Co. Division, Detroit Steel Products Co., *Pittsburgh.*

RUSSEL, COLIN, manager, Russel Brothers, Ltd., *Fort Frances, Ont., Canada.*

SAKIYAMA, JISABURO, military assistant engineer, Japanese Army Office, *New York City.*

SALKIN, M., draftsman, Oil Well Supply Co., *Oil City, Pa.*

SARTELL, PAGE M., assistant mechanical engineer, Aeronautical Engine Laboratory, United States Navy Yard, *Philadelphia.*

SHOEMAKER, JAMES J., research engineer, Engineers' Aircraft Corp., *Stamford, Conn.*

SIKORSKY, IGOR I., vice-president in charge of engineering, Sikorsky Aviation Corp., *Bridgeport, Conn.*

SISSON, GLEN R., engineer, carbureter controls division, Pierce Governor Co., *Anderson, Ind.*

SMITH, JAMES J., salesman, The White Co., *Long Island City N. Y.*

SNADER, IRA J., production engineer, Wright Aeronautical Corp., *Paterson, N. J.*

SWANCAR, JOSEPH EDWARD, head of commercial division, Ford Motor Co. of Canada, Ltd., *East Windsor, Ont., Canada.*

TAGOE, ANDREW BURGGERSEN, automobile mechanic, director of works, Handy-Andy Workshops, *Dodoweh, South Africa.*

TAYLOR, PERCIVAL JOHN, proprietor and chief engineer, P. J. Taylor & Co., *Sydney, N. S. W., Australia.*

TURNAMIAN, HARRY M., weight control, aeronautical, General Development Co., *New York City.*

WALKER, AVERY W., sander department engineer, The Carborundum Co., *Niagara Falls, N. Y.*

WILLIAMS, C. E., carbureter engineer, Cadillac Motor Car Co., *Detroit.*

WINTERROLL, ADOLF, designer, General Development Co. of Connecticut, *New York City.*

ZONGKER, C. E., master mechanic and consultant to the trade, Commercial Grinding & Motor Co., *Tulsa, Okla.*

Notes and Reviews

AIRCRAFT

Water-Pressure Distribution on a Twin-Float Seaplane. By F. L. Thompson. Report No. 328. Published by the National Advisory Committee for Aeronautics, City of Washington, 1929; 18 pp., illustrated. [A-1]

This is the second of a series of investigations to determine water-pressure distribution on various types of seaplane floats and hulls. It consisted of measuring water pressures and accelerations on a TS-1 seaplane during numerous landing and taxying maneuvers at various speeds and angles.

The results of this investigation show that water pressures as great as 10 lb. per sq. in. may occur at the step in various maneuvers and that pressures of approximately the same magnitude occur at the stern and near the bow in hard pancake-landings with the stern well down. At other parts of the float the pressures are less and are usually zero or slightly negative for some distance abaft the step. Approximate load-distribution curves for the worst landing conditions are derived from the data obtained to serve as a guide in static tests.

The Torsional Strength of Wings. By C. P. Burgess. Report No. 329. Published by the National Advisory Committee for Aeronautics, City of Washington, 1929; 14 pp., 6 figures. [A-1]

This report describes a simple method for calculating the position of the elastic axis of a wing structure having any number of spars. It shows that strong drag-bracing near the top and bottom of a wing greatly increases the torsional strength. An analytical procedure for finding the contribution of the drag bracing to the torsional strength and stiffness is described. This is based upon the principle of least work and involves only one unknown quantity.

The validity of the new method of analysis is tested by applying it to a two-fifths-scale model of the large steel tubular three-spar wing of the Huff-Daland XHB monoplane. The calculated stresses are checked by comparison with the strains observed by means of electric-telemeter strain-gages secured to the spars during sand-load tests in the static testing laboratory of the Army Air Service Engineering Division at Dayton, Ohio.

The torsional strength of a wing very largely determines the distribution of air forces upon it and the tendency of the wing to flutter. Insufficient torsional strength produces wash-in or an increasing angle of attack toward the wing tips in the high-incidence condition, further increasing the load on the front spar in the condition which is already the most severe. Conversely, torsional yielding in the low-incidence and nose-dive conditions produces wash-out of the wing shape and may exaggerate the critical condition for the rear spar.

A coefficient for comparing the torsional rigidity of different wings is derived in this report.

Collection of Wind-Tunnel Data on Commonly Used Wing-Sections. By F. A. Louden. Report No. 331. Published by the National Advisory Committee for Aeronautics, City of Washington, 1929; 43 pp., 55 figures, 49 tables. [A-1]

This report was prepared, at the request of the National Advisory Committee for Aeronautics, in the Bureau of Aeronautics of the Navy Department so as to group in a uniform manner the aerodynamic properties of commonly used airplane wing-sections as determined from tests in various wind-tunnels.

The data have been collected from reports of a number of laboratories. Where necessary, transformation has been made to the absolute system of coefficients, and tunnel-wall interference corrections have been applied. Tables and graphs present the data in the various forms useful to the engineer in the selection of a wing section.

Tests of Large Airfoils in the Propeller Research Tunnel, Including Two with Corrugated Surfaces. By Donald H. Wood. Report No. 336. Published by the National Advisory Committee for Aeronautics, City of Washington, 1929; 19 pp., illustrated. [A-1]

This report gives the results of the tests of seven 2 x 12-ft. airfoils; Clark-Y, smooth and corrugated, Gottingen 398, N.A.C.A. M-6, and N.A.C.A. 84. The tests were made in the propeller research tunnel of the National Advisory Committee for Aeronautics at Reynolds numbers up to 2,000,000. The Clark-Y airfoil was tested with three degrees of surface smoothness.

The effect of small variations of smoothness of an airfoil is shown to be negligible. Corrugating the surface causes a flattening of the lift curve at the burble point and an increase in drag at small flying angles.

Airplane Drag. By Carl Töpfer. Translated from *Die Luftwacht*, September, 1929. Technical Memorandum No. 544; 15 pp., 4 figures. [A-1]

The Balance of Moments and the Static Longitudinal Stability of Airplanes. By Horst Müller. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Jan. 28, 1929. Technical Memorandum No. 545; 12 pp., 8 figures. [A-1]

Structural Details of the Giant Dornier Seaplane Do-X. By Corrado Gustosa. Translated from *Rivista Aeronautica*, October, 1929. Technical Memorandum No. 546; 25 pp., illustrated. [A-1]

The foregoing three Technical Memoranda on aircraft design were issued during December by the National Advisory Committee for Aeronautics, City of Washington. Two other Memoranda which also appeared during that month are listed in this issue under Engines and Material respectively.

Spinning. By J. D. Blyth. Part I, The Aerofoil; Part II, The Aeroplane in Free Flight. Published in *Flight*, Engineering Section, Oct. 25, and Nov. 29, 1929. [A-1]

"The basic cause of spinning is autorotation of the wings following a stall," declares Colonel Blyth. The nature and cause of this autorotation are set forth with deliberate avoidance of any but the more simple mathematics, thus placing the explanation within the scope of anyone possessing elementary knowledge of algebra. The first part of the article deals with the part played by the airfoils, while the second part considers the effect on spinning properties of the machine as a whole.

(*Continued on next left-hand page*)

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

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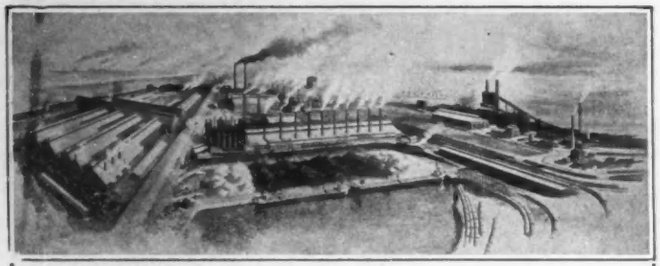

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Notes and Reviews

Continued

Lichtreflexion von Rotierenden Propellern. By V. S. Kulebakin. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Nov. 28, 1929, p. 586. [A-1]

A hazard of night flying here studied is the discomfort and possible temporary blinding of the pilot by the reflection of light rays from the rotating propeller. Propellers, being for the most part highly polished, reflect light almost as brightly as would a mirror; and the situation becomes acute when the pilot is trying to land in a brilliantly illuminated field where strong beams strike the propeller. The fact that the pilot's eyes have become accustomed to the dark makes the sudden access of light all the more disconcerting.

In this article data are given on the maximum amount of light that may strike the pilot's eyes without causing discomfort. Results are also presented of a photometric investigation into the amount and type of light due to beams striking from various angless propellers given different types of finish. The conclusion is drawn that the least harmful results are obtained when the propeller is covered with a flat-black finish. Such a finish was found to detract in no way from the aerodynamic properties of the propeller.

Fifteenth Annual Report of the National Advisory Committee for Aeronautics, 1929. City of Washington; 89 pp. [A-3]

The latest annual report of the National Advisory Committee for Aeronautics is now available. It covers the organization of the Committee, its general activities, reports of the technical committees, lists of the technical publications issued during the year and a very interesting and valuable summary of progress in aircraft development.

Aviation from the Ground Up. By G. B. Manly. Published by Frederick J. Drake & Co., Chicago, 1929; 373 pp., illustrated. Price $3.50. [A-31]

This volume, embracing facts that everyone should know about aviation, is one of several that have been offered during the last year or two in answer to the public demand for non-technical literature on aeronautics.

The writer, a pilot since before the World War, has been closely associated with the accomplishments by aircraft that have created this world-wide interest. He states in his preface that he has endeavored in this book to pass along the information which he fervently wished might have been given to him in the early days of his training.

As suggested by the title, the subject is reviewed from the early history of the first flights through the developments of later years in improved planes, engines, methods of construction and production, instruments, equipment, navigation, landing-fields and the art of flying.

The Aircraft Handbook. By F. H. Colvin, editor of *American Machinist*, and H. F. Colvin. Fourth edition. Published by McGraw-Hill Book Co., Inc., New York City and London, 1929; 682 pp. and index. Price $5. [A-3]

The fourth edition of the well-known Colvin Aircraft Handbook has just made its appearance. Much of the material in the previous editions that is obsolete has been deleted, although the Curtiss OX-5 engine is retained because of its wide use in small planes. Similarly, the Hispaño-Suiza is still used though not now manufactured.

The book contains a chapter on Simple Airplane Theory; a description of airplane types; a chapter on rigging and servicing; an airplane-engine section with detailed descriptions of the Curtiss Challenger, the Pratt & Whitney Wasp and Hornet, the Wright Whirlwinds, the Bliss Jupiter, the LeBlond "Sixty," the Velie M-5, the Warner Scarab, and two small, four-cylinder engines from English designs—

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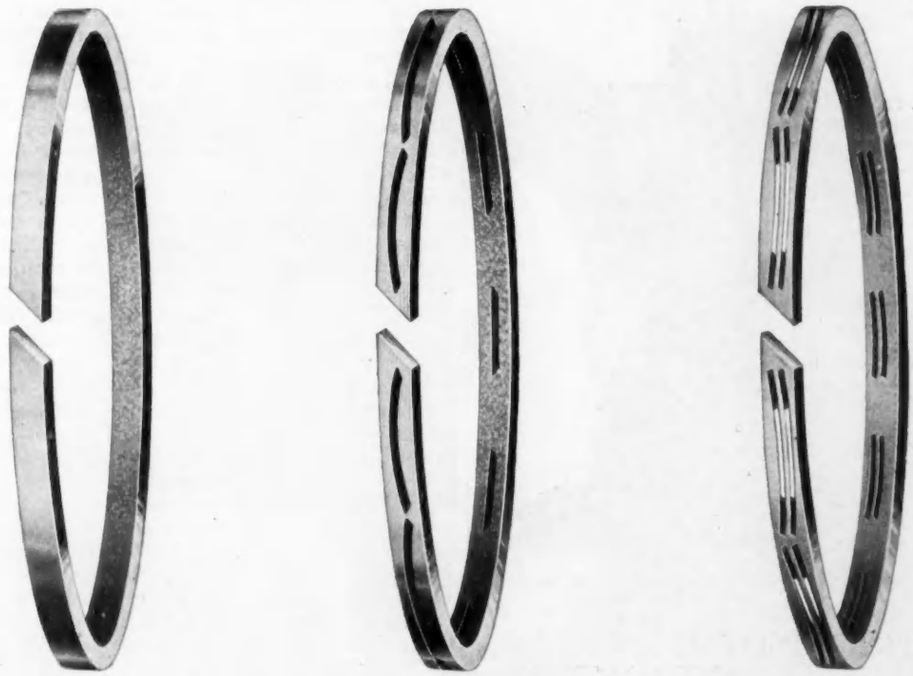

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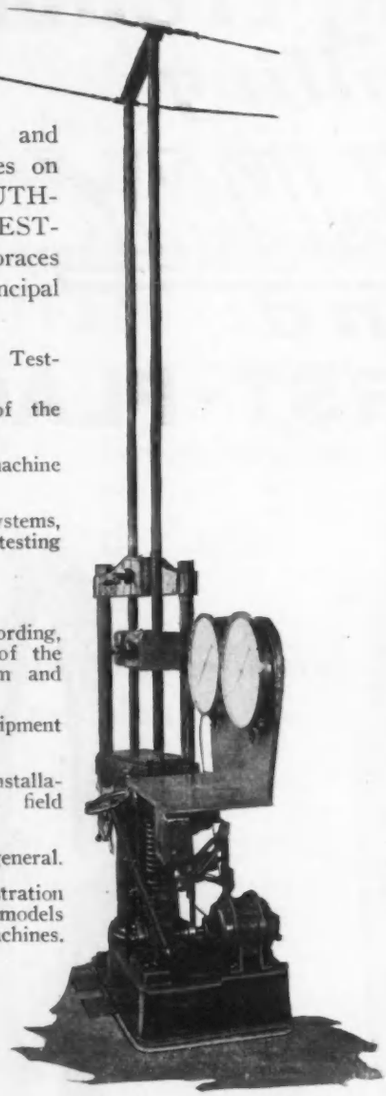

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Notes and Reviews

Continued

the Cirrus Mark III and the Gipsy. There are also chapters on trouble-shooting, the propeller, engine and plane accessories, and on aircraft instruments.

The latter part of the book is concerned with airplane construction, materials and the S.A.E. standards, to which much attention is given. Other chapters are on airships and dirigible balloons, the building and equipment of airports, the construction of aircraft and the licensing of pilots, air traffic rules, and the nomenclature for aeronautics by the National Advisory Committee for Aeronautics.

The book, as usual, is well bound in green fabricoid.

F. L. F.

The Air Annual of the British Empire. Founded and edited by Squadron-Leader C. G. Burge, O.B.E., A.R.Ae. S.I. Published by Gale & Polden, Ltd., London; vol. I, 1929; 710 pp., and index. Price, 21 shillings. [A-3]

In characteristic English fashion the first Air Annual of the British Empire contains 93 sections, made up of authoritative articles on the history and progress of aviation in the British Empire, contributed by well-known officials and civilians throughout the Empire. The material is grouped under the main headings of: Empire Aviation, Service Aviation, Civil Aviation, Africa, Australia, Canada, India, New Zealand, Imperial Air Services, Flying Clubs, Air Survey and Photography, and The British Aircraft Industry. Subdivisions cover Aero Engines both air- and water-cooled, Aircraft Instruments, Aircraft Accessories and Supplies, Australian Aircraft Manufacturers, and Canadian Aircraft Manufacturers. The book is a veritable storehouse of British aeronautical information. It is especially well illustrated and contains many useful maps and tables, some of which are in colors.

Issued ten years after the first American aeronautical yearbook, which appeared in February, 1919, under the imprint of the Aircraft Manufacturers' Association, it sets a new standard which our own Aeronautical Chamber of Commerce might well equal or exceed. It is evident that a portion of the cost of publication is borne by some 42 pages of advertisements taken by the trade.

A valuable list of abbreviations in common use in British service and civil aeronautics occupies two pages in the front of the book. There is a general index, and indices of aircraft, engines, accessories and names. F. L. F.

R-101. Published in *Flight*, Oct. 11, 1929, p. 1088. [A-3]

In publishing this article, the editors have aimed to collect in one issue the main data and such information as can be given concerning the airship R-101, together with a brief summary of the history of the airship program which has resulted in the completion of two rigid airships. One of these, the R-100, has been designed and built by private enterprise (the Airship Guarantee Co.), and the other, the R-101, partly by the State, as represented by the Air Ministry and the Royal Airship Works, and partly by private firms, notably Boulton & Paul, Ltd.

The article is liberally illustrated.

Airplane Welding. By T. B. Johnson, M.E., Chief of Material Branch, Materiel Division of the Air Corps. Published by the Goodheart-Wilcox Co., Inc., Chicago, 1929; 295 pp. and index. Price $3.50. [A-5]

The wide use of welding in the construction of automobiles and airplanes makes this book of more than usual interest. Only a few books have been written on welding and these cover special fields; therefore this book will be of special interest to automotive engineers who are specializing in airplane construction.

The author discusses methods of joining aircraft structures by mechanical methods and by soldering, brazing, and gas and electric welding; also the materials used for

(*Continued on next left-hand page*)

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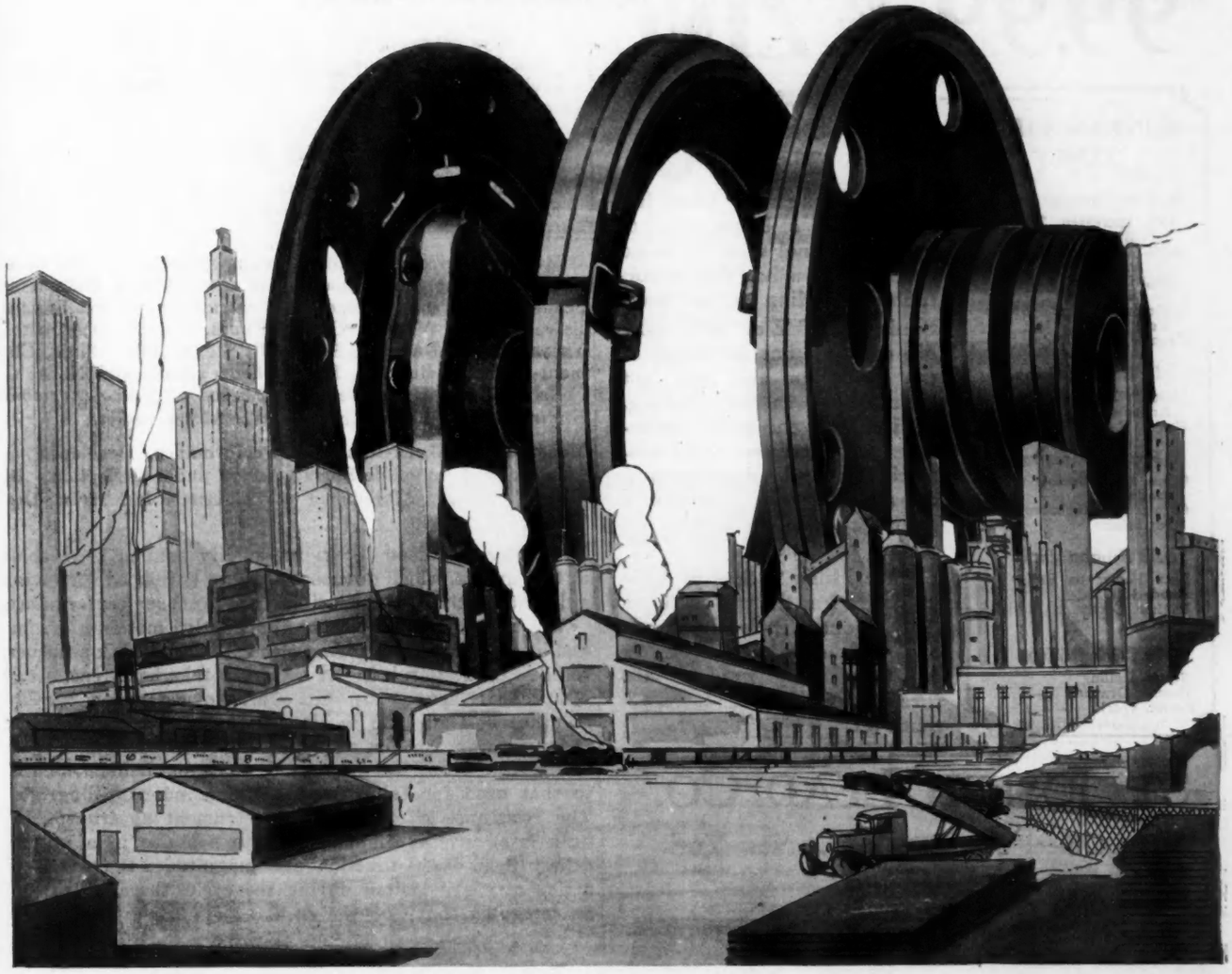

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Notes and Reviews

Continued

aircraft construction, the design of welded joints, and the manufacture of welded structures. A special chapter is included on the welding of aluminum parts and the welding of special metals, such as monel metal, high nickel-chromium stainless steel, Stellite, special steels and cast irons.

Valuable appendices give data on Underwriters' Laboratories Standards for Construction and Performance of Acetylene Generators, Polishing and Etching for Microscopic Examination of Steel, Design Loads for Circular and Streamline Struts, Substitution of Mild-Carbon for Chrome-Molybdenum Steel Tubing for Repair Purposes, and other important tables. F. L. F.

Weighted Cables Raise 360-Ton Arches in Airship Dock. Published in *Engineering News-Record*, Dec. 5, 1929, p. 874. [A-5]

The procedure followed in erecting the series of 13 arch-truss ribs and fill-in bracing comprising the framework of the Goodyear-Zeppelin airship factory and hangar at the Akron airport was quite as novel as is the structure itself. This article describes the three principal operations involved in placing each erection unit, which comprised a complete bay, consisting of a pair of ribs with rafters, purlins and bracing: first, erecting the haunch sections on steel falsework with locomotive cranes; second, assembling the center sections on similar but lower steel falsework and hoisting them to position between the haunches by counterweighted cables assisted by lines reeving over the locomotive crane-drums; and, third, placing the rafters, purlins and bracing in the bays between those already erected, using a stiff-leg derrick traveler on top of the erected steelwork, the same traveler later lifting into place the arch ribs of the doors at either end.

CHASSIS PARTS

The Case for the Independently Sprung Wheel. By W. M. Evans. Published in *The Automobile Engineer*, August, 1929, p. 308. [C-1]

Mr. Evans presents an interesting statement of the problem comparing the orthodox and unorothodox systems in general terms and including illustrations of the Lancia, Selve, Sizaire, Vomag, Cottin, Faudi, Tracta, Desgouttes, Tatra, Austro-Daimler, Scammell, Steyr, Röhr, Alvis, Clement-Rochelle, Bucciali, Harris Leon Laisne and N. A. G.

Delay in receiving the August issue of *The Automobile Engineer* accounts for the tardiness of the review.

Measure of Shock-Absorber Performance Developed as Index of Automobile Spring Action under Deflection. By E. W. Weaver. Published in *Automotive Industries*, Dec. 14, 1929, p. 870. [C-1]

Another attack on the riding-quality enigma is revealed in this article, which describes a device developed for giving a definite method of measuring shock-absorber performance.

The author points out that the relative motion of frame and axle actuates the moving element of the shock-absorber, the link connection being of a type to take both tensile and compressive stress. In an effort to determine the instantaneous load, both in direction and in magnitude, that is imposed on the link as the spring goes through a cycle of operation, use has been made of a mechanism similar to that used for taking steam-engine indicator-diagrams. The resistance offered by the instrument as transmitted by a lever arm is communicated to a stylus in a way to deflect it in both direction and magnitude, to record its action at every instant during the cycle, thereby drawing an irregular shape on the card.

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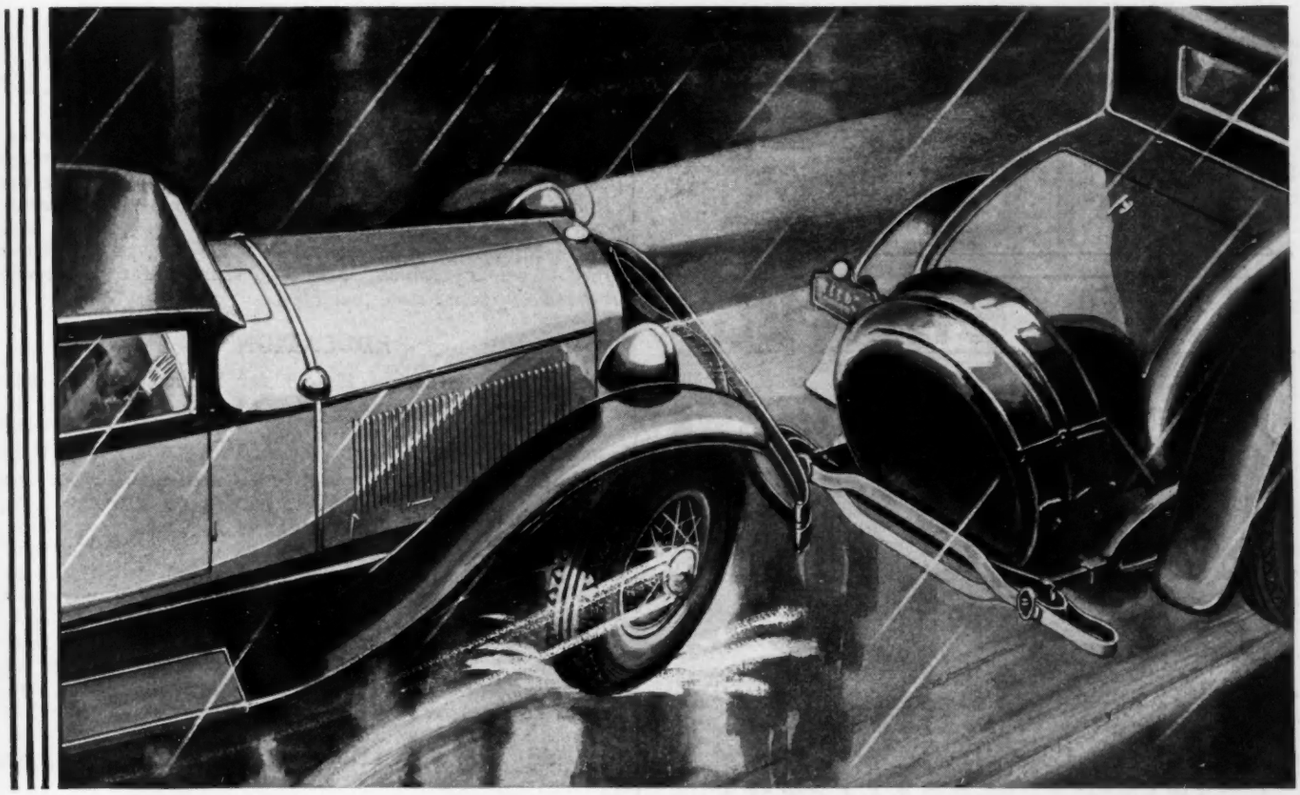

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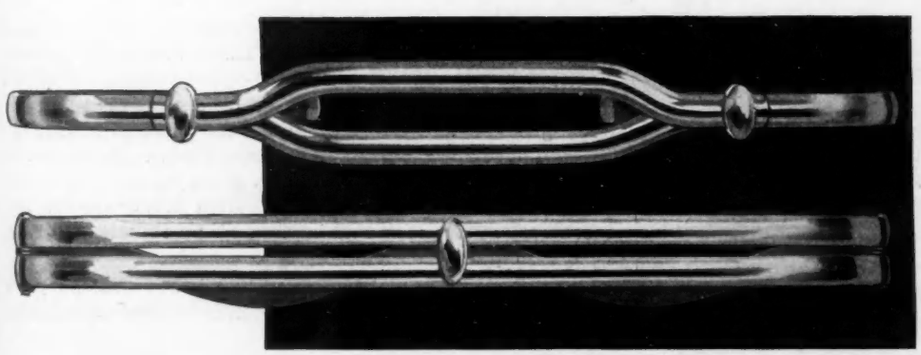

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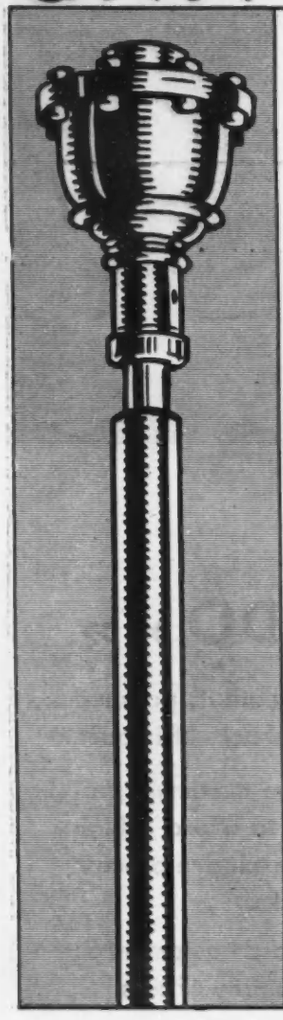

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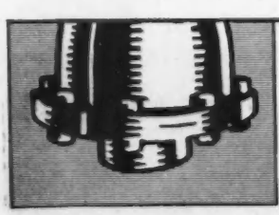

Notes and Reviews

Continued

Several uses are predicted for the development; namely, (*a*) as a laboratory tool in the development of control instruments, (*b*) as a recording inspecting method for the product, (*c*) in connection with chassis springs and mountings, to develop spring suspension of the vehicle, and (*d*) in connection with service-station work, in which the present immeasurables leave opportunity for argument between the seller and customer.

EDUCATION

Engineering Education. Essays for English selected and edited by Ray Palmer Baker, Ph.D. Second edition, revised. Published by John Wiley & Sons, Inc., New York and London, 1928; 233 pp. Price, $2. [D-3]

Selected from authors who are distinguished authorities in their respective fields, this collection of essays will be a welcome addition to the library of any engineer who is interested in developing a command of English, particularly that having to do with the exposition, description or discussion of scientific subjects. Combining both early and contemporary authors and coverng a wide variety of subjects, this volume will serve as a valuable reference book as well as a guide to good diction. It is divided into 14 articles grouped under seven main headings: The Origins of Engineering Education, The Types of Engineering Education, The Bases of Engineering Education Language, Mathematics, Physics, Chemistry, Imagination and Invention.

Dr. Baker is a professor of English and head of the Department of Arts, Science, and Business Administration, at the Rensselaer Polytechnic Institute at Troy, N. Y. The book is attractively bound in a red cover. F. L. F.

ENGINES

The Strength of Shafts in Vibration. By J. Morris, B.A., A.F.R.Ae.S. Published by Crosby Lockwood & Son, London, 1929; 189 pp. Price, 30 shillings. [E-1]

This book is a record of various mathematical researches by the author into problems connected with the investigation of vibration in shafts. The main features of this work are the general mathematical results obtained for any number of loads on a shaft in vibration, whether lateral (with or without imposed rotation) or torsional.

The plan adopted has been to deal with the general theory first and then to append a few examples taken from practice, indicating what assumptions, empirical or otherwise, are made to bring the problems within range of solution.

Fahrzeug-Dieselmotoren. By A. E. Thieman. Published by R. C. Schmidt Co., Berlin, Lutherstrasse 14, 1929; 286 pp. Price, RM 17. [E-1]

Due to the considerably greater difference in price between gasoline and fuel oil, the Diesel engine in Europe has been developed to a practical powerplant for automotive equipment and is used as such to a great extent. It is not unexpectedly that one finds a thorough treatment of the precombustion-chamber engines and an all-round, inspiring 68-page chapter about fuel-injection devices.

The way in which the author criticizes Dr. Diesel's part of the development of the Diesel engine is very surprising, coming from a German author.

Mr. Thieman is an independent author, and as such has avoided the borrowing of more or less out-of-date drawings and figures from any Diesel-engine manufacturer. He does not believe in mathematical treatments so common with German authors, but strikes a practical balance between theory, speculative designing and practical results.

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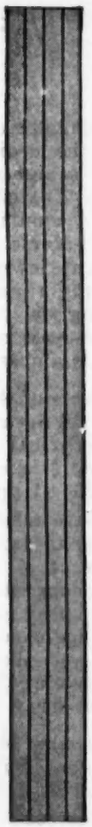

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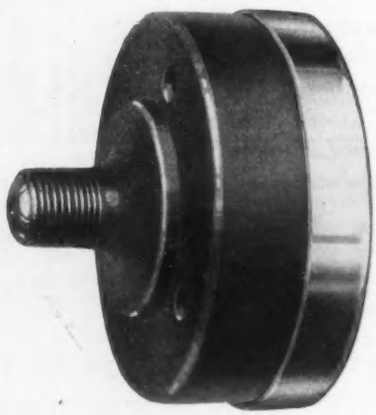

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Notes and Reviews

Continued

In his chapter on actually built Diesel engines the author includes the ordinary hot-bulb engine, which has developed into a high-pressure engine. As an example he mentions the English Petter and shows three development stages. A similar development has taken place with the Fairbanks-Morse engines in this Country. The Bagnulo light-weight low-pressure engine is shown in detail, as representing a line of development very popular in Europe.

Summing up, the author believes in the coming of the two-stroke-cycle oil-burning engine, the final development of which is a question of a suitable blower. H. M.

Some Effects of Air Flow on the Penetration and Distribution of Oil Sprays. By A. M. Rothrock and E. G. Beardsley. Technical Note No. 329. Published by the National Advisory Committee for Aeronautics, City of Washington, 1929; 11 pp., 16 figures. **[E-1]**

Tests were made at the Langley Memorial Aeronautical Laboratory to determine the effects of air-flow on the characteristics of oil sprays from fuel-injection valves. The work was done with the N.A.C.A. spray photography equipment, the spray chamber of which was altered to simulate an oil-engine combustion-chamber of the vertical disc type.

Curves and photographs are presented showing the air-flow throughout the chamber and the effects of the air-flow on the fuel-spray characteristics.

Engine Design Moves in a New Direction. By Earl F. Theisinger. Published in *Bus Transportation*, November, 1929, p. 598. **[E-1]**

The motorcoach powerplants displayed at Atlantic City during the American Electric Railway Association convention are described and illustrated, and the general design trends as shown by the new models are outlined in this article.

Six-cylinder models predominated, two manufacturers are using eights, and only one company retained the four. This situation, the author points out, is in considerable contrast to that which existed less than five years ago, when fours were supreme, sixes experimental and eights virtually unthought of for motorcoach service. The ability to deliver higher torque at lower speeds is another notable feature, while evidence is at hand that other fuels than gasoline are being seriously considered as a future source of power. A Diesel-type engine, an oil-burning steam powerplant and a conventional engine adapted to run on either fuel oil or alcohol were among the exhibits.

On the whole, the tendencies, according to Mr. Theisinger, are toward smoother operation and better all-round performance without adversely affecting fuel economy or operating costs. This is apparent in changes in carburetion and manifolding and in improved cooling. Popularity of the overhead valves, especially in powerplants for heavy-duty service, and a general use of materials such as silchrome for valves, which promise longer life for the new engines, are noted. Improved manufacturing methods evident in the finished product also contribute to this last-named quality.

Performance Characteristics of Automobile Fans under Test Indicate Size Should Be as Large as Radiator Permits. By L. Boelter. Published in *Automotive Industries*, Nov. 23, 1929, p. 754. **[E-1]**

The capacity of the radiator for dissipating heat depends upon the weight of air filtering through it, which in turn depends upon (*a*) the fan, (*b*) the velocity of the vehicle relative to the wind, and (*c*) the physical condition of the radiator. Thus, the author analyzes this phase of engine cooling.

In the tests conducted at the University of California, eight types of fan commonly employed in automobiles were compared. These included seven having pressed-steel blades

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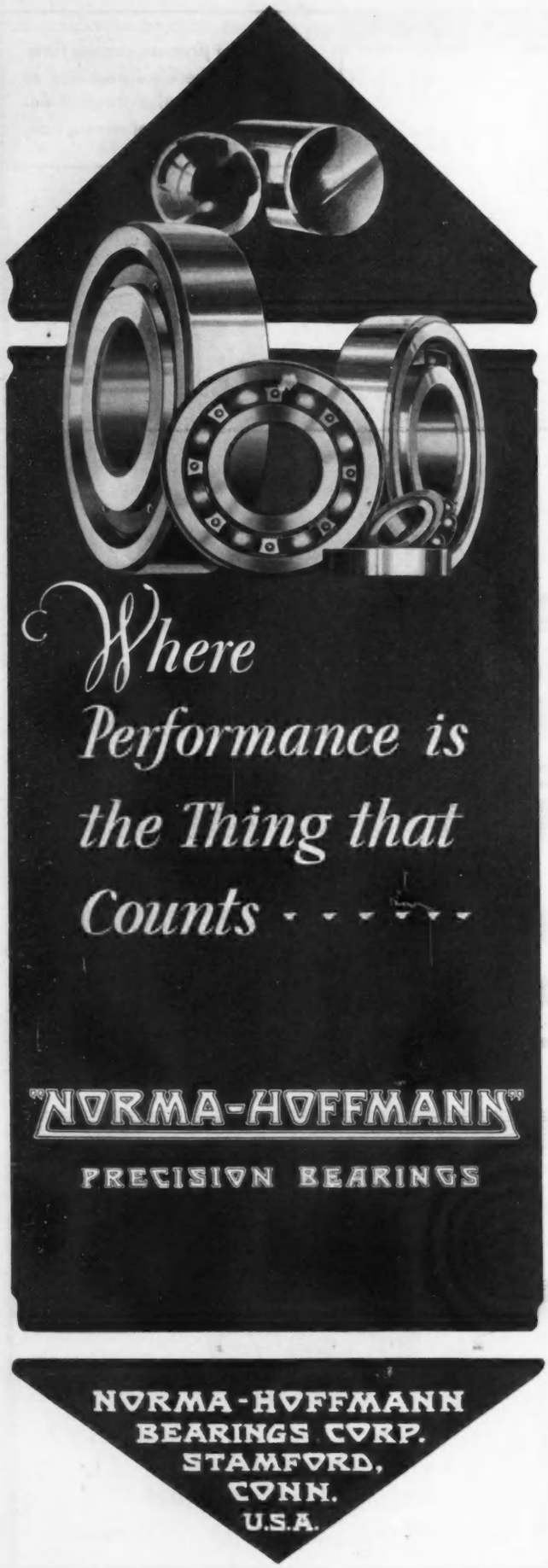

Notes and Reviews

Continued

of constant pitch and one cast-aluminum variable-pitch fan. From the results of the tests of the eight fans, curves are plotted showing the rate of air discharge as a function of fan speed, the horsepower required to drive the fan as a function of fan speed, and the rate of air discharge per horsepower input to the fan as a function of fan speed. Prof. Boelter concludes that for maximum fan efficiency the fan should be as large as the radiator will permit, and for a given rate of air discharge a fan turning at a low speed is more efficient than one turning at a high speed.

Investigation of the effect of the distance of the fan from the radiator showed that the fan should be run as close to the radiator as possible unless a shroud is used which, when properly designed, greatly increases the rate of air discharge with no increase in power consumed.

A study of the effect of car motion on the velocity of air passing through the radiator results in the conclusion that, without a fan, air filters through the radiator at approximately half the velocity of the car.

Dieselflugmotoren. By A. B. Thiemann. Published in *Illustrierte Flugwoche*, October, 1929, p. 203. [E-1]

Tracing the history of Diesel aircraft-engines, the author reviews briefly the early developments, dating from the World War, during which attempts were made to carburet heavy fuels in a heated carbureter, firing the mixture with a spark-plug, and later, still retaining electric ignition, to inject fuel directly into the combustion-chamber. The impediments to the successful operation of both of these systems are pointed out. Only in recent years, the author states, have the methods of obtaining a good homogeneous air-fuel mixture, with the necessary turbulence, been firmly grasped.

By the end of the war, Beardmore had begun experiments which resulted in the appearance in 1927 of an eight-cylinder in-line airship engine. A six-cylinder airplane engine also was produced. Both of these are described in this article and details given as to materials used, fuel systems and other particulars.

The Garuffa two-stroke-cycle heavy-oil engine, of Italian make, is noted as the next development. It is of the nine-cylinder radial type, water-cooled and supercharged. The supercharger has two speeds. The output is about 330 hp. and the engine has a weight of about 1 kg. (2.205 lb.) per hp. A 12-cylinder V-engine put out by the same firm was hailed at its appearance as of great promise but has not been heard of since.

The Sunbeam, the Attendu, the Junkers, which is said to have completed recently a 3-hr. trip without any untoward incident, and the Packard are other engines described.

Impediments to be overcome before the Diesel will be generally acceptable for aircraft work are said to be high cost of production, sensitiveness in operation and a tendency to show considerably greater specific fuel-consumption in the hands of users than on the test bench. An advantage that the Diesel will undeniably bring in its wake, asserts the author, is the use of the two-stroke cycle.

Die Vorkammergrösse und ihr Einfluss auf das Arbeitsverfahren der Vorkammer-Dieselmaschinen. By Hans Mehlig. Published in *Automobiltechnische Zeitschrift*, Nov. 20, p. 723, and Dec. 10, 1929, p. 783. [E-1]

In this article the author presents mathematical analyses, confirmed by tests, of the effects of various factors on the operation of a precombustion-chamber type of Diesel engine. Among the factors so investigated are variations in engine speed, relative size of precombustion chamber, temperature of compression and the application of heat during compression.

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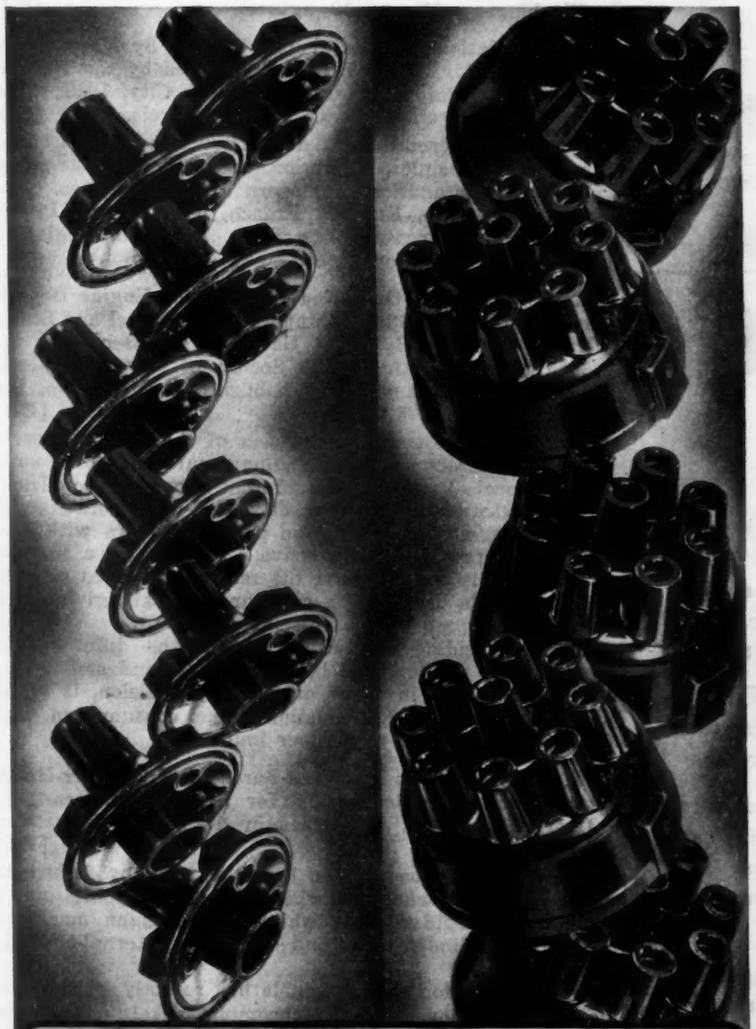

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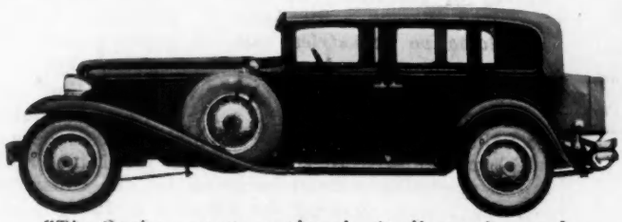

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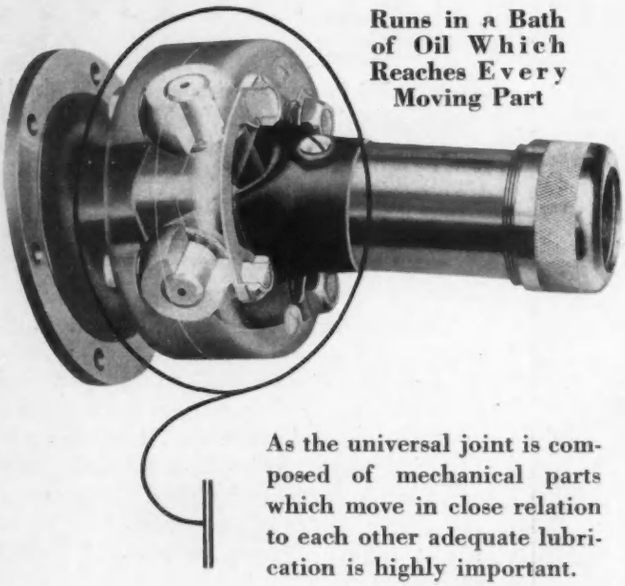

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Notes and Reviews

Continued

Calculation on the Pressures on Aircraft-Engine Bearings. By O. Steingenberger. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, March 14, 1929. Technical Memorandum No. 543. Published by the National Advisory Committee for Aeronautics, City of Washington, 17 pp., 19 figures. [E-1]

Modern Aviation Engines. Vols. I and II. By Major Victor W. Pagé, Air Corps, U.S.R. Published by the Norman W. Henley Publishing Co., New York City, 1929; totaling 1908 pp., and indices. Price, two vols., $9. [E-3]

This is a reference work and instruction manual covering basic principles, operation, inspection, construction, repair and installation of modern aviation engines. The leading American, English, French, German and Italian aeronautical engines are described. Each chapter is followed by questions for review.

Comparisons of the Operating Costs of the Engine Departments of United States Shipping Board Diesel and Steam Cargo Vessels. By R. D. Gatewood. Presented at the 39th general meeting of the Society of Naval Architects and Marine Engineers and published in *Motorship*, December, 1929, p. 875. [E-4]

The paper presents a tabulation of the costs of operation and maintenance of the engine departments of a number of vessels having three different types of propulsion; namely, Diesel-engine direct drive, oil-fired boilers with reciprocating-engine drive, and oil-fired boilers with turbine double-reduction gear drive. Figures on a number of voyages are included and the results presented on both a cost-per-mile basis and a cost-per-day basis, giving also the average speed of the vessels.

The outstanding conclusion is that the difference in cost per day or per mile between Diesel and steam propulsion, which is in favor of Diesel propulsion, is virtually all obtained by the reduction in fuel consumption, with fuel oil costing more money per unit.

White Iron Edges on Machined Surfaces of Cylinder-Heads and Blocks Are Responsible for Economic Losses. By George M. Eaton. Published in *Automotive Industries*, Nov. 30, 1929, p. 792. [E-5]

Many and serious are the losses entailed by failure to meet production schedules, which the author points out is often due to epidemics of white-iron edges on machined surfaces of cylinder-heads and blocks for internal-combustion engines.

An investigation of the trouble has recently been made, including unalloyed irons, chromium-nickel irons, and chromium-molybdenum irons. In more than 90 per cent of the individual white-iron-edged castings investigated, the hard edge was due to the presence on the rough casting of a fin which landed on the edge and acted as a chill. Other variables that tend to produce white-iron edges are high chromium, low silicon, low total carbon, cold-poured metal and wet sand.

Modification of foundry design and pattern practice, focusing attention on the rough casting, with continued vigilance in foundry practices, are the solutions offered.

Survey of Machining Practice for Both Slotted and Unslotted Pistons. By Athel F. Denham. Published in *Automotive Industries*, Oct. 12, 1929, p. 518. [E-5]

Five pistons were selected for study: that of Continental Motors, typifying the production line on which manufacturing flexibility of a high order is required; the La Salle piston, representing the higher-priced class of cars, which are offered to the consumer for fairly high-speed initial operation without breaking in; the Oldsmobile six-cylinder piston, showing the relation to fairly high quantity production; the Reo and the Viking pistons. The major operations in machining practice were considered

(*Continued on third left-hand page*)

OFFICIAL AUTO-LITE SERVICE

2,177,266 MOTOR CARS WERE EQUIPPED WITH AUTO-LITE IN 1929

Each year more automobile manufacturers realize that starting, lighting and ignition systems of the greatest reliability and highest quality are of paramount importance to the prestige of their car. That has been the reason why more than 2,177,266 motor cars — were equipped with Auto-Lite during 1929. The Electric Auto-Lite Company, Office and Works: Toledo, Ohio. Also makers of Dé Jon

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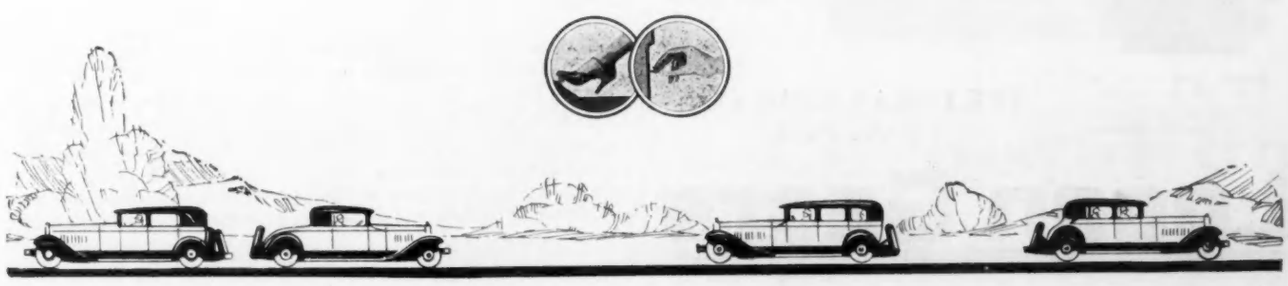
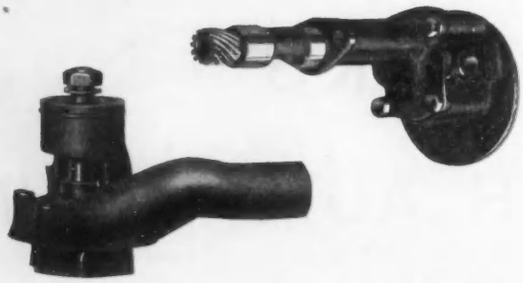


Pump and Gear Service That Cuts Production Costs



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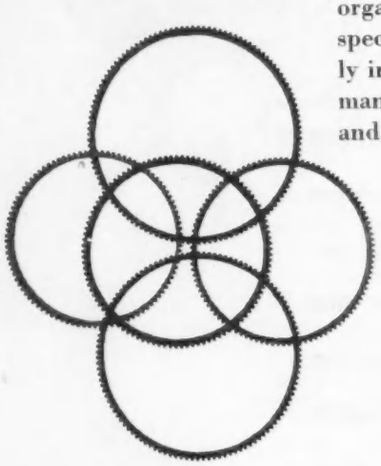

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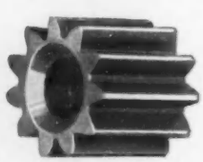

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Logan Gears

Notes and Reviews

Continued

and tabulated. The results show considerable variation among companies, while the actual turning, cutting and grinding processes differ with the type of unit used.

MATERIAL

Applied Chemistry Reports. Vol. XIII, 1928. Issued by the Society of Chemical Industry, London; 693 pp. and index, running to 741 pp. [G-1]

This is the regular annual report issued by the Society of Chemical Industry on the progress of applied chemistry, and covers: General, Plant and Machinery; Fuel; Gas, Carbonization, Tar and Tar Products; Mineral Oils; Coloring Matters and Dyes; Fibers, Textiles, Cellulose and Paper; Bleaching, Dyeing, Printing and Finishing; Acids, Alkalis, Salts, etc.; Glass; Refractories, Ceramics and Cements; Iron and Steel; Non-ferrous Metals; Electro-chemical and Electro-metallurgical Industries; Oils, Fats and Waxes; Paints, Pigments, Varnishes and Resins; India-Rubber; Leather and Glue; Soils and Fertilizers; Sugars, Starches and Gums; The Fermentation Industries; Foods; Sanitation and Water Purification; Fine Chemicals, Medicinal Substances and Essential Oils; Photographic Materials and Processes; and Explosives; also a valuable name-index and subject index.

T. F. Burton, B.S., is editor. Thirty-four authorities have contributed to this volume, which contains several hundred valuable footnotes as well. F. L. F.

Gas-Locking Tendencies of Aviation Gasolines in Airplane Fuel Lines and Feed Pumps. By C. C. Moore, Jr., and M. S. Reynolds. Paper presented at tenth annual meeting of the American Petroleum Institute, Chicago, Dec. 4, 1929. [G-1]

This paper reports the results of an experimental investigation to determine the effect of gasoline volatility on the tendency of aviation gasolines to gas-lock in fuel lines and feed-pumps, and thus pave the way for predicting fuel performance from a knowledge of its volatility.

The data were secured by ascertaining the pumping rates of several gasolines covering a wide range of volatility. An electrically operated gasoline-pump and a system of fuel lines and reservoirs, in which the atmospheric pressure and gasoline temperature could be varied independently, provided conditions corresponding to those encountered in aviation practice.

Conclusions arrived at are that the data indicate a definite relationship between the vapor-locking tendency of a gasoline and its 10-per cent point on the distillation curve of the American Society for Testing Materials, that a rough indication may be deduced from the average boiling-point of the gasoline, and that the initial boiling-point is a less satisfactory indication of vapor-locking tendency.

Graphic charts have been developed for use in determining the relative performance of aviation gasolines at various altitudes and temperatures from a consideration of the 10-per cent point in the A.S.T.M. distillation.

The paper, Vapor Pressures of Gas-Free Gasolines, by Oscar C. Bridgeman, Elizabeth W. Aldrich, and Hobart S. White, reports the results obtained in the fuel-research work at the Bureaus of Standards. Progress on this investigation is reported in papers presented at the Society's meetings.

Variations de la Température d'Allumage Spontané des Carburants Additionnés en Pourcentage Variable de Plusieurs Corps. By A. Grebel. Published in *Le Génie Civil*, Nov. 30, 1929, p. 541. [G-1]

The present article supplements reports of work previously done to ascertain the effect of varying additions of a number of substances on the spontaneous-combustion temperatures of gasoline. In cases in which the substance to

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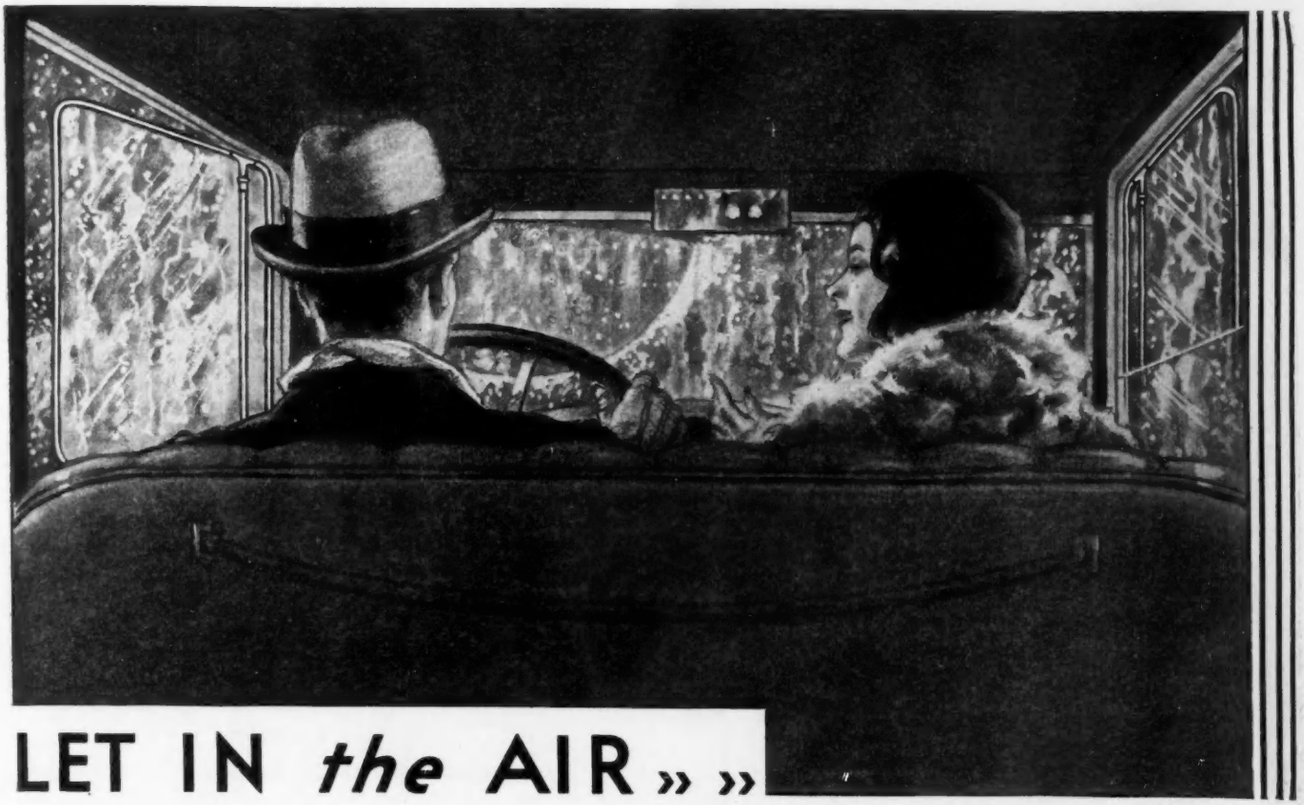

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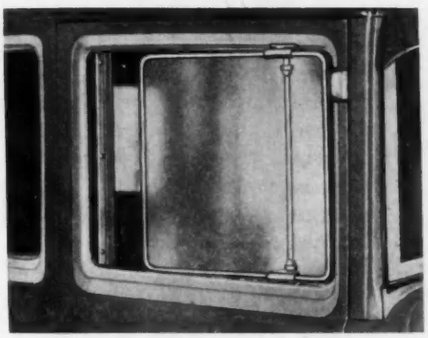

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Notes and Reviews

Continued

be added was not soluble with gasoline, a 50-per cent blend of gasoline and benzol was used as the basic fuel. To make the work practically applicable, only mixtures stable above 14 deg. fahr. and of reasonable price were included.

The first set of tests comprised blends of gasoline, benzol and ethyl alcohol, the percentages of the first two varying from 0 to 100, and of the last from 0 to 50. From the second set of tests, one of these blends (50 per cent gasoline, 30 per cent benzol and 20 per cent ethyl alcohol), which gave a spontaneous combustion temperature of 57 deg. fahr. above that of pure gasoline, was used as the basic substance. To this was added acetone and aniline in amounts varying from 0 to 5 per cent of the base.

Conclusions are drawn as to the practical desirability of various mixtures from the viewpoint of economy and smooth operation.

Contribution to the Study of Normal Burning in Gaseous Carbureted Mixtures. Part I. By M. R. Duchêne. Translated from *Service Technique et Industriel de l'Aéronautique Bulletin Technique No.* 54, December, 1928. Technical Memorandum No. 547. Published by the National Advisory Committee for Aeronautics, City of Washington; 18 pp., 10 figures. **[G-1]**

MISCELLANEOUS

Wage Incentive Methods: Their Selection, Installation and Operation. By Charles Walter Lytle, M. E., Director of Industrial Cooperation, New York University. Published by The Ronald Press Co., New York City, 1929; 442 pp. and index. Price, $7.50. **[H-5]**

Methods of arousing self-interest and thus securing the best workmanship and greatest production have always been of interest to industrial executives. This book will be found valuable in setting up base rates and individual job-rates, and installing incentive plans, such as single-piece, multiple-piece, combined-time, bonus and piece-rate plans. The several types of profit-sharing arrangements are discussed, also empirical plans, with and without step bonuses, and incentive plans for indirect work and supervision. The final chapter is for supervisors, office employes and executives. In the appendix methods are given for studying incentive plans. Illustrations and examples have been drawn from 67 important American industrial institutions.

F. L. F.

Machine Design. By P. H. Hyland and J. B. Kommers. Published by McGraw-Hill Book Co., Inc., New York City, 1929; 431 pp. and index, illustrated. Price, $4. **[H-5]**

The authors, both of whom are professors at the University of Wisconsin, state that their chief aim in preparing this book is to provide a textbook from which to teach the elements of machine design. The material has been arranged in an order that experience with classes has indicated is teachable and convenient for both the student and the instructor. It is this arrangement and the choice of material which Professors Hyland and Kommers set forth as original, rather than the actual subject-matter. Enough material on kinematics has been included in the volume to make unnecessary the provision of a separate text on that subject.

The chapters cover general considerations affecting design, shop processes, linkwork, cams, materials of construction, fundamental mechanics, riveted joints, screw fastenings, keys, shafting, toothed gears, friction and lubrication, and safety engineering design.

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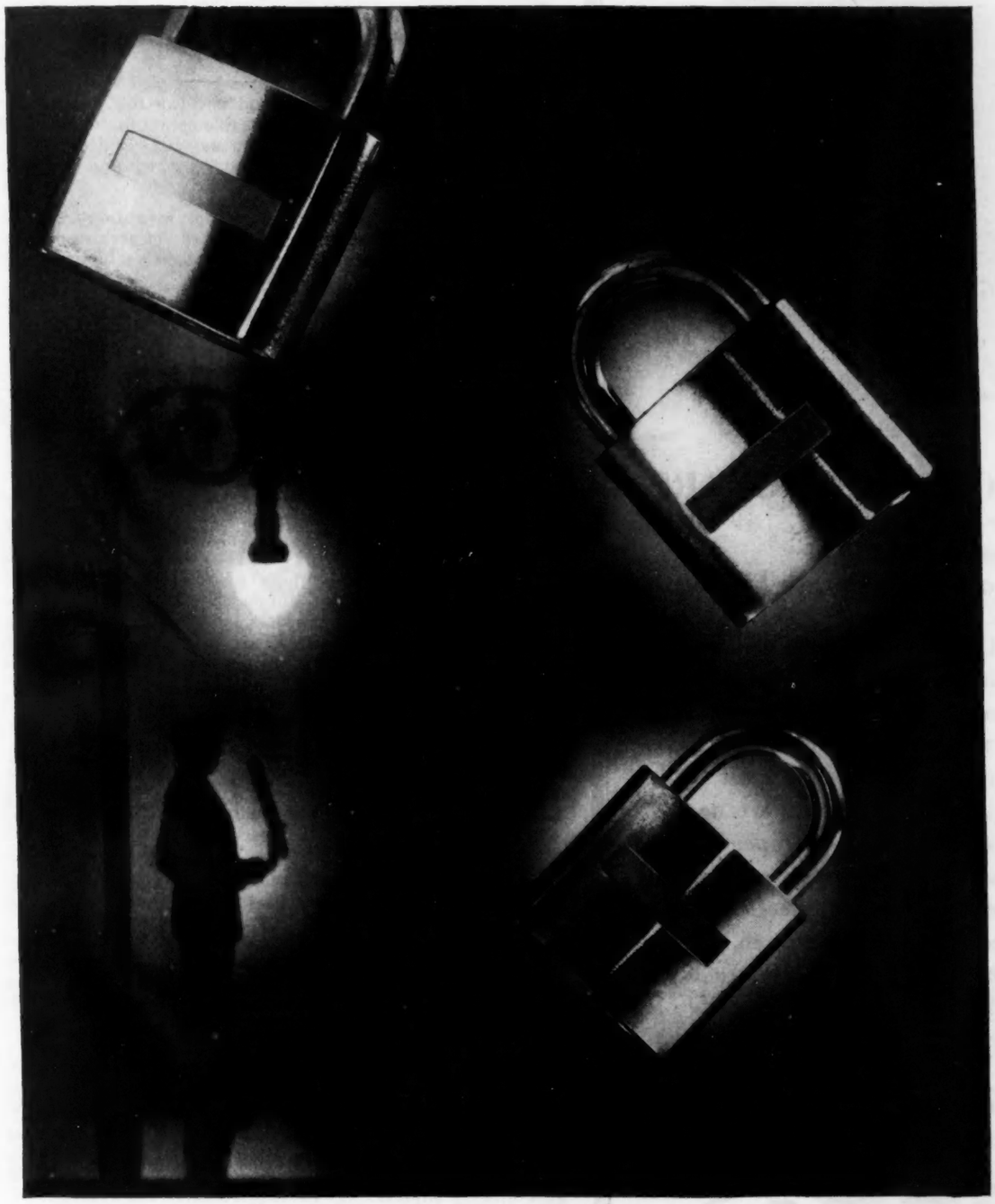

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Notes and Reviews

Concluded

Quality Control and Production Gages. By Earle Buckingham. Presented at the Annual Meeting of the American Society of Mechanical Engineers. Dec. 2 to 6, 1929, New York City. [H-5]

The author discusses the basic principles entering into the use of production gages and reviews the progress in the development of interchangeable manufacturing. He urges that tolerances be as large as will result in satisfactory operation, and contends that drawings and specifications should give these tolerances.

An analysis of data received from manufacturers regarding cost of inspection and percentage of scrapped parts is included. An excellent and comprehensive bibliography is appended.

MOTORCOACH

What's New in Bus Design. By Earl F. Theisinger. Published in *Bus Transportation*, October, 1929, p. 524. [J-1]

"Plenty of new things to talk about," states the author of this article, in which he reviews the American Electric Railway Association exhibition at Atlantic City, N. J. Chassis designed to give better service with less servicing, distinctive body designs, and engines reflecting the last word in power and performance, are the general trends noted, while a comprehensive list of other features and smaller items are described. Among the new developments noted are the 34 and 41-passenger Yellow parlor coaches powered by a new six-cylinder overhead-valve engine; a 21-passenger single-engine automotive street-car by Twin Coach; new BK and BC models by Mack; new bodies by Bender, Lang, Fitzjohn, Fremont and Superior; 150-hp. engines by Sterling and Continental; and a new Ross steering-gear.

A second installment of this article discusses the most important items of powerplant design. The review of the latter appears in this issue, classified under Engine Design.

TRACTOR

Research in Mechanical Farm Equipment—1928. By R. W. Trullinger. Published in *Agricultural Engineering*, November, 1929, p. 357. [M-1]

This review of the outstanding results of mechanical farm-equipment studies during the last year speaks well for the efforts of the United States Department of Agriculture Advisory Council on Research in Mechanical Farm Equipment. Investigations of problems in traction machinery, engine fuels, tillage machinery, harvesting and threshing machinery, grain cleaning and crop-drying equipment, and dairy equipment are reported.

Engineering Applied to Agriculture. By H. B. Walker. Published in *Agricultural Engineering*, November, 1929, p. 341. [M-3]

Engineering in agriculture has attained great impetus in the United States through the extensive use of mechanical power, declares the author, who is professor of agricultural engineering and agricultural engineer of the Agricultural Experiment Station of the University of California. He presented this paper at the World Engineering Congress in Tokio, Japan, last November as the representative of the American Society of Agricultural Engineers.

The general acceptance of mechanical power by farmers has stimulated new ideas in equipment design, such as automatic operations. Trends in tractor design show greater fuel economy, less weight per horsepower, greater field speeds and greater efficiency in the transmission of power. Diesel-engine tractors are gaining recognition. These are only a few of the salient points brought out in the paper, which describes the influence of machinery on production methods in farming and in turn on the social environment of the worker.

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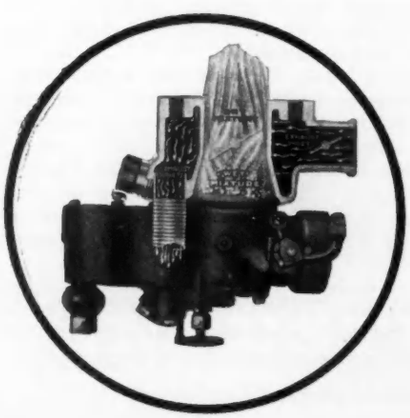

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BATTERIES

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Personal Notes of the Members

(Continued from p. 295)

grade in 1926. His paper, A Motor Vehicle for House-to-House Deliveries, appeared in the S.A.E. JOURNAL for January, 1928, p. 87. He is a member of the Chicago Section, and last year acted as its Secretary.

Slack Joins G. M. Export Co.

Fred W. Slack has become connected with the General Motors Export Co., after resigning as vice-president and chief engineer of the Peerless Motor Car Corp. He is now associated with the overseas division of the export company and is scheduled for early work abroad.

Mr. Slack has been identified with the automotive industry since its early days. After completing his scholastic education, he entered the employment of the Packard Motor Car Co. in 1903 as draftsman and designer. Three years later he joined the Chalmers-Detroit Co. as research and experimental engineer, and in 1909 became engineer for the Peerless Motor Car Co., with which organization he remained until his change of position herein reported. He advanced from the position of assistant chief engineer to the post of chief engineer in 1923, and last year was elected vice-president of the Peerless Company.

Since becoming a Member of the Society in 1917 Mr. Slack has served on the Parts and Fittings Division of the Standards Committee in 1924 and on the Cooperative Advisory Committee on Automobile Locks in 1926.

Announcementt has been made that **Carroll M. Aument** has been advanced from production manager to factory manager of both the Teterboro and the Passaic plants of the Fokker Aircraft Corp., of New York City.

Frederick W. Beinecke announces that he has relinquished his post as president of the Studebaker Sales Co., of Newark, N. J., and is now a partner in the brokerage firm of Coady, Beinecke & Co., of New York City.

Charles E. Burns, Jr., who has been employed by the Union Switch & Signal Co., of Swissvale, Pa., as engineer, has severed this connection to become mechanical designer for the Silica-Gel Corp., of Baltimore.

Robert W. Butler, a former engineer with the R. U. A. Butler Co., of Jenkintown, Pa., has joined the Treiber Diesel Engine Corp., of Camden, N. J., as engineer.

Fred C. Chandler, Jr., a former member of the production department of the Chandler Motor Car Co., of Cleveland, is now president of the Accurel Metal Products Corp., also of Cleveland.

Kwang H. Chang, a former student training as a designer with the Packard Motor Car Co., is now employed as a tool designer by Chrysler Motors, in Detroit.

Roland Chilton, who until recently was chief engineer for the Aeromarine Starter Co., of Keyport, N. J., is now consulting engineer for the Wright Aeronautical Corp., of Paterson, N. J.

S. J. Cooper is now in the service of the Packard Motor Car Co. as factory representative. He was formerly service manager for the John H. Thompson Co., of Detroit.

Frederick C. Crawford, who has been serving Thompson Products, Inc., in the capacity of general manager of the Detroit plant, has been elected first vice-president and general manager of the entire organization.

Rex C. Darnell, until lately head of the experimental development and statistical division of the engineering department of the Willys-Overland Co., is now chief engineer for the Taylor Bros. Mfg. Corp., of Elkhart, Ind.

George C. Davies has become affiliated with the Vacuum Oil Co., of New York City. Previous to making his new connection, Mr. Davies was research engineer's assistant, at the Elizabeth, N. J., plant of the Standard Oil Development Co.

L. Disbrow, formerly designer for the International Business Machine Corp., of New York City, is now engaged in design work in the special equipment department of the International Motor Co., also of New York City.

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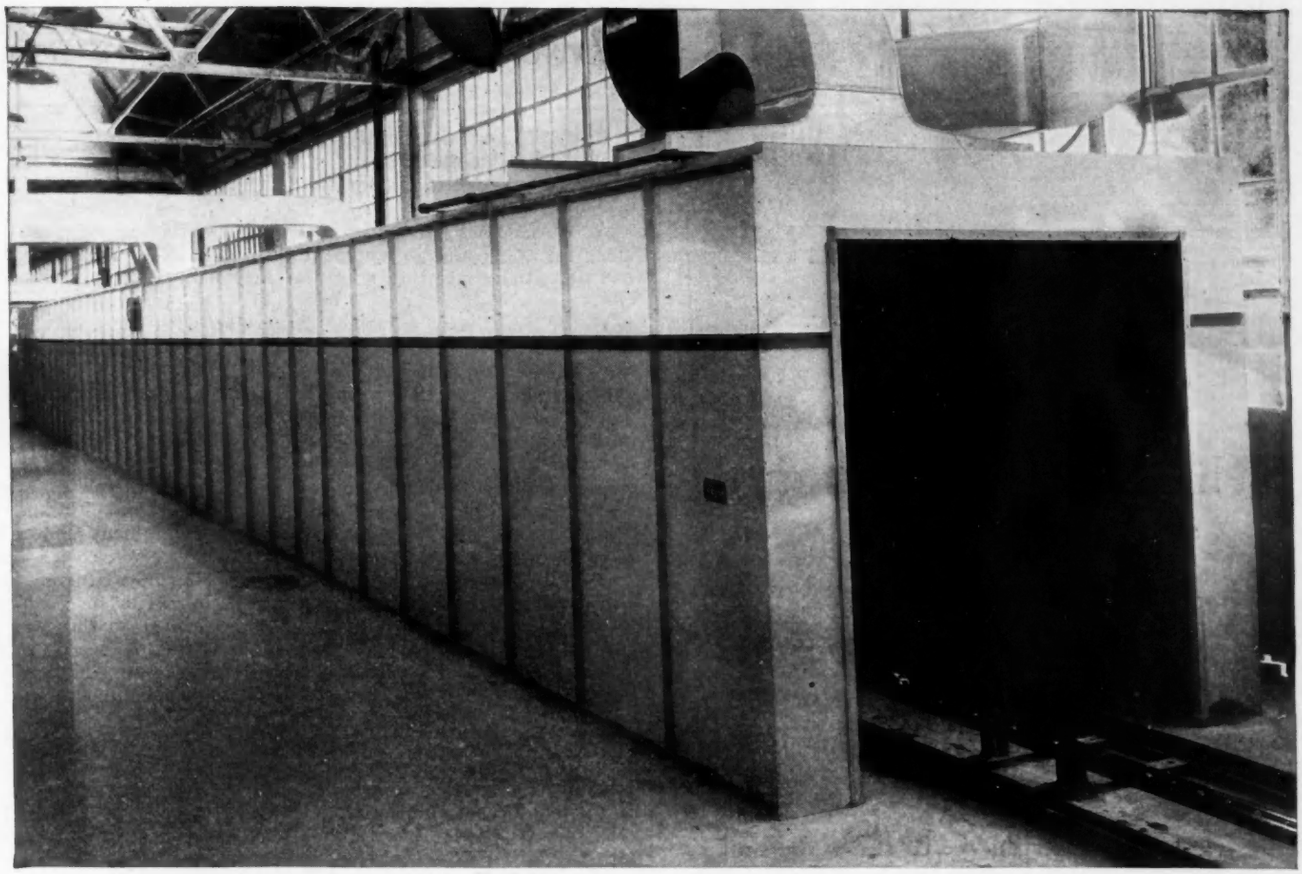

A Mahon Standard Unit Drying Oven installed over a conveyor line in a large automobile body plant

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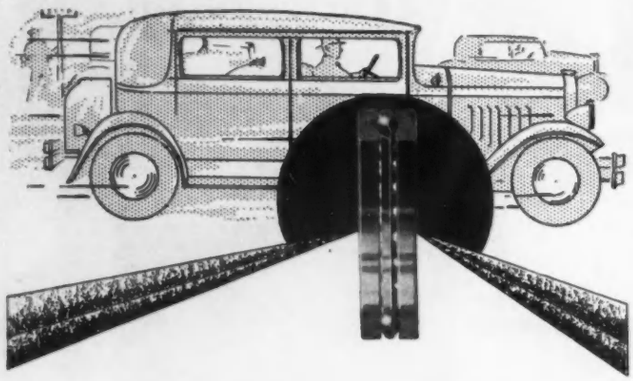

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Under the floor-board of the finest American motor cars is a set of B. C. A. Bearings, quietly performing an indispensable service in a most important place. In these days of crowded traffic, necessitating easy and rapid operation of the clutches, our thrust and angular contact bearings play an important part in the cars you sell. In the clutch release and pilot positions they guarantee trouble-free performance. Leading automobile manufacturers consult our bearings engineers. They are at your service.

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Personal Notes of the Members

Continued

Harry S. Durland, until recently industrial service engineer for the American Laundry Machinery Co., of New York City, is now superintendent of the Union Laundry Co., Inc., of Newark, N. J.

A. W. Einstein, who previously was statistical merchandiser for the Hahn Department Stores, of New York City, has accepted a position with the A. Polsky Co., of Akron, Ohio.

Victor R. Ellison, a former draftsman with the Glenn L. Martin Co., of Baltimore, is now a powerplant designer for the Great Lakes Aircraft Corp., of Cleveland.

Nathaniel Ely is now a junior patent engineer and attorney for Hammond & Littell, of New York City. He was until lately patent attorney for the Kolster Radio Corp., of Newark, N. J.

George B. Emerson, formerly owner of the Emerson Motor Parts Co., of Detroit, has recently been made treasurer and superintendent of the Industrial Heating Equipment Co., of Detroit.

John R. Emerson is now in the engineering department of the Marvel Carburetor Co., of Flint, Mich. Prior to establishing this connection he was a sales engineer in the carbureter division of the Penberthy Injector Co., of Detroit.

John Ericson, a former designer for the Famous Players-Lasky Corp., of Hollywood, Calif., is now a mechanical engineer for the Miami Copper Co., of Miami, Ariz.

A. W. Fitzpatrick has relinquished his position as educational service manager with the Hart-Parr Co., of Charles City, Iowa, to become service manager for the Oliver Farm Equipment Co., of Charles City, Iowa.

Harlan D. Fowler has left his position as chief engineer with the Miller Corp., of New Brunswick, N. J., and is now serving the Fokker Aircraft Corp. of America, at Hasbrouck Heights, N. J., as designing engineer.

L. I. Friedlaender, a former mechanical engineer with the Briggs Mfg. Co., of Detroit, is now a research engineer in the standards division of the H. H. Franklin Mfg. Co., of Syracuse, N. Y.

After recently severing his connection with the Spartan Aircraft Co., Inc., of Tulsa, Okla., as chief research engineer, **Dr. W. Friedrich** has accepted appointment as research engineer for the Fokker Aircraft Co., of Hasbrouck Heights, N. J.

Roscoe H. Fuller, having recently resigned his position as assistant chief engineer of Rolls-Royce of America, Inc., has become associated with the Heald Machine Co., of Worcester, Mass.

Frank L. Grant, formerly assistant factory sales manager of the Gabriel Snubber Mfg. Co., has joined the sales department of the Midland Steel Products Co., of Cleveland.

T. H. Harkness has left the service of the Stephen S. Nerney Co., of Hollywood, Calif., for which he was a sales engineer, and accepted a similar position with Maddux, Inc., of Los Angeles.

After leaving the Kissell Motor Car Co., of Hartford, Wis., for which he was chief draftsman, **A. J. Hazen** has joined the engineering staff of the Wisconsin Axle Co., of Oshkosh, Wis.

J. W. Hobbs has severed his connection as factory manager for the Galesburg Coulter-Disc Co., of Galesburg, Ill., and is now sales manager for the Mechanics Universal Joint Co., of Rockford, Ill.

Thorleif Holthe, until lately aircraft engineer with Columbia Airliners, Inc., of Long Island City, N. Y., is now production engineer with the Sikorsky Aviation Corp., of Stratford, Conn.

Roy W. Johnson has assumed the duties of chief engineer with the John W. Brown Mfg. Co., of Columbus, Ohio. He previously was engineer with the Paraflector Co.

E. A. Keeley, former secretary-treasurer of the Splitdorf Electric Co., of Newark, N. J., is now in charge of the sales division for automotive devices in the Wilcolator Co., also of Newark.

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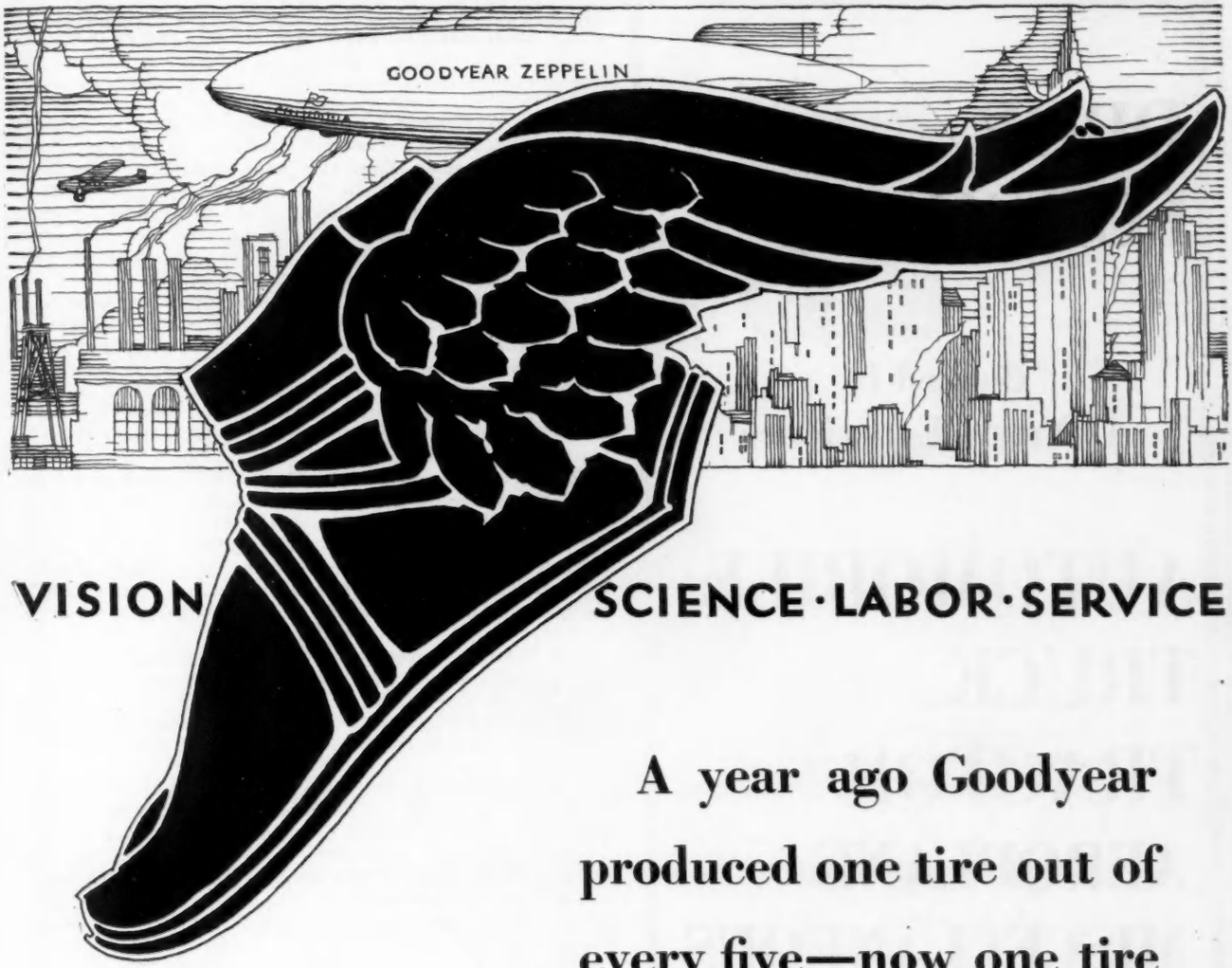

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Personal Notes of the Members

Continued

Arthur W. Kimbell is now treasurer and general manager of the United Carr Fastener Corp., of Cambridge, Mass. Previously to establishing this connection he was president and general manager of the Cinch Mfg. Corp., of Chicago.

F. W. Lampe, who until lately was employed as a technical man by the Chrysler Corp., has severed that connection to accept a position as experimental engineer with the Precision Balancing Machine Co., of Minneapolis.

Carleton John Lauer, formerly a research engineer with the Kelvinator Corp., is now a member of the engineering department of Chrysler Motors, Inc., at its Highland Park, Mich., plant.

A. J. Leaver, until recently principal partner of A. J. & G. A. C. Leaver, of Brisbane, Australia, has entered the independent field as consulting engineer, with offices at Newmarket, Queensland, Australia.

John B. Lewis, a former inspector of motorcoaches for the Key System Transit Co., of Oakland, Calif., is now an agent for the National Union Insurance Co., of San Francisco.

W. C. Lockwood, who has legally changed his name from Losowich, is now serving the Fellows Gear Shaper Co., of Springfield, Vt. His former connection was with the Eclipse Machine Co., of East Orange, N. J., as experimental engineer.

Bart Lund, a former student of electrical engineering at Purdue University, is now owner of the Byrne Battery Co., of St. Louis.

George Albert Lyon announces that he is president of the Lyon Cover Co., of Detroit, which manufactures metal tire covers.

J. N. Mahoney, who has been manager of engineering for the Sperry Gyroscope Co., of Brooklyn, N. Y., is now president of the Herbert Bucklin Corp., of Elkhart, Ind.

Charles Marcus, previously resident manager for the Eclipse Machine Co., of East Orange, N. J., has been made president of that company.

C. N. Maurer, who was identified with the Wisconsin Highway Commission, at Madison, Wis., in the capacity of traffic engineer, is now director of highway sales for the Heil Co., of Milwaukee.

John F. McMahon, until recently vice-president in charge of service for the Yellow Taxi Corp., of New York City, has relinquished that post to become supervisor of maintenance for the Parmlee Transportation Co., also of New York City.

E. J. Meehan, having left the Divco Detroit Corp., where he was in charge of the experimental department, is now a trailer inspector with Whitehead & Hales, of River Rouge, Mich.

William P. Meeson, formerly works manager for the Hillman Motor Car Co., of Coventry, England, is now general manager of the Blackburn Aircraft Co., of Borough East York, England.

Elton W. Miller, until lately senior mechanical engineer on the National Advisory Committee for Aeronautics, at Langley Field, Hampton, Va., is now chief of the Aerodynamics Division.

Hugo Moren has left the independent field of consulting engineering to enter the employment of the Reflex Engineering Corp., of Newark, N. J.

Richard L. Mullaney, until lately a ground-school instructor for the Curtiss Flying Service, Inc., of Toledo, Ohio, has been appointed assistant national director of schools for the Curtiss Wright Flying Service, of Grosse Ile, Mich.

Richard L. Newell has relinquished his position as draftsman for the Hall-Scott Motor Car Co., of Berkeley, Calif., and is now a body draftsman with the North Coast Transportation Co., of Seattle, Wash.

Lieut.-Commander George O. Noville has accepted the post of general manager to the Hawaiian Airways, Ltd., of Honolulu, Territory of Hawaii. His former connection was that of technical supervisor with the Marchetti Motor Patents, Inc., of San Francisco.

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2/3rds —

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Rollway Solid Cylindrical Roller Bearings

—during the nineteen years of their existence have withstood the severest conditions and loads met in the basic industries.

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Personal Notes of the Members
Continued

G. R. Ohmart, who was assistant to the chief engineer with the General Necessities Corp., of Detroit, is now employed in a similar capacity by the Absopure Refrigeration Corp., also of Detroit.

Gustaf Peterson, who until recently was district manager of sales for the Atlas Steel Corp., of Dunkirk, N. Y., is now occupying a similar position for the Ludlum Steel Co., of Philadelphia.

W. S. Reed, a former partner of S. & R. Associated, of Detroit, has assumed new duties as consulting engineer for the Niagara Motors Corp., of Dunkirk, N. Y.

Charles E. Richardson has become identified with the Belgian Leather Corp., of New York City, as engineer. His previous connection was with the Hyatt Roller Bearing Co., of Harrison, N. J., where he was a jig and tool designer.

Harry M. Rugg has relinquished his post as engineer in charge of sales-promotion equipment for the Vacuum Oil Co., of New York City, and become an instructor in the college of technology of the University of New Hampshire, at Durham, N. H.

H. D. Runciman, whose connection with the Nice Ball Bearing Co., of Philadelphia, was that of sales manager, is now vice-president in charge of eastern sales for the Strom Steel Ball Co., of Cicero, Ill.

Charles E. Sargent has joined the consulting engineering department of the Westinghouse Electric & Mfg. Co., of East Pittsburgh. Before making this connection he was in the independent field as a consulting and research engineer.

Barrett E. Sibley, formerly chief engineer for the Continental Oil Co., of Denver, has been appointed to the position of chief technologist with that company.

William A. Simms, a former student of Cornell University, is now employed at the Kearny, N. J., Branch of the Western Electric Co. as a junior engineer in manufacturing development.

James H. Skelley, who until lately was an engine designer with the Willys-Overland Co., of Toledo, has accepted a position as engineering representative with the Auburn Automobile Co., of Auburn, Ind.

George A. Smith, former technical editor of the Motor Boat Publishing Co., of New York City, is now a member of the technical staff of the American Bureau of Shipping in the same city.

G. W. Smith, Jr., who has been technical assistant to the vice-president, general manager of the White Motor Co., of Cleveland, has recently been appointed vice-president in charge of production with that company.

Harry G. Smith has been appointed vice-president and operations manager for the China Airways Federal, Inc., U. S. A., of Shanghai, China. His former connection was that of chief engineer of Aero Engineering & Advisory Service, Inc., of New York City.

J. Allan Smith, former president of the Ner-A-Car Corp., of Syracuse, N. Y., is now vice-president of the Twin Coach Co., located at Kent, Ohio.

Wesley Dixon Smith, whose connection with the Motor Rim & Wheel Service of California, in Los Angeles, has been that of general manager, has been elected president of that company.

William E. Smith, former superintendent of welding with the Ford Motor Co., at Detroit, is now welding engineer with the Murray Corp. of America, also located at Detroit.

L. F. Southwick has relinquished his post as assistant to the general manager of the Godward Gas Generator, Inc., of New York City, to become a member of the manufacturing and service division of the Vacuum Oil Co., also in New York City.

John R. Stanley, until recently general manager for the Stanley-Bradt Auto Co., of Alexandria, La., is now manager of the automotive parts department of the Interstate Electric Co., of Shreveport, La.

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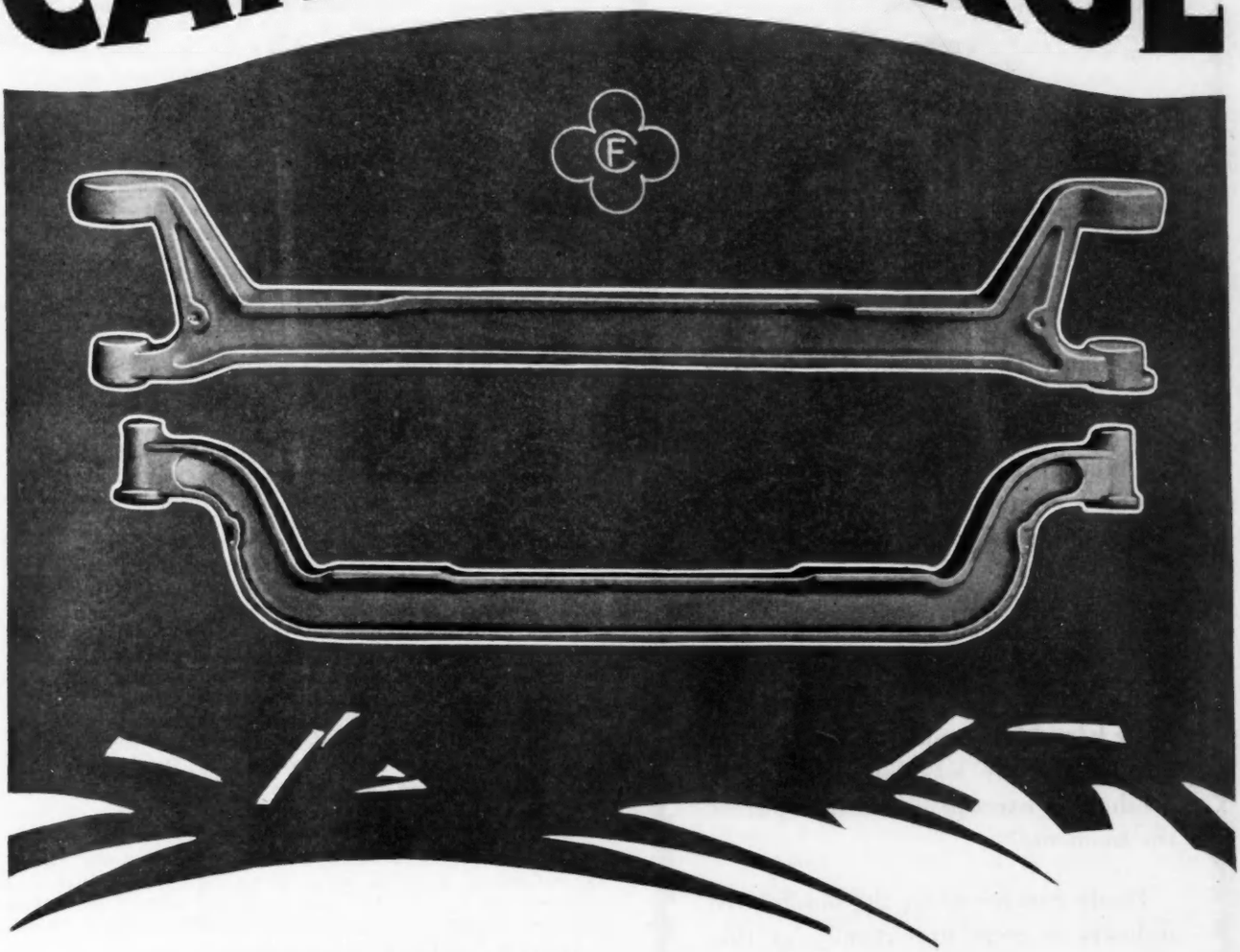

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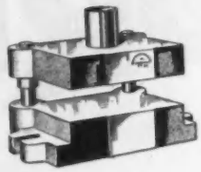

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Personal Notes of the Members

Continued

C. H. Starr, who has been serving the Willard Storage Battery Co. as vice-president and general manager of the Canadian branch in Toronto, has been made vice-president and general manager of the Los Angeles, Calif., branch.

Louis M. Stellman, formerly half-owner and vice-president of the Mastercrafts Corp., of Brattleboro, Vt., is now assistant chief engineer for the Wright Aeronautical Corp., of Paterson, N. J.

J. A. Stein recently became superintendent of service and repairs for the E. Allen Test Co., of Stockton, Calif. His former connection was as automobile mechanic shop-foreman in the Division of Highways Department of Public Works, at Redding, Calif.

W. H. Stephens recently relinquished his position as automotive maintenance engineer for the Continental Oil Co., of Denver, and is now shop superintendent for the Stovell Hilliker Co., of the same city.

William R. Stroud, who was serving the Van Sciver Corp., of Philadelphia, as a truck inspector, has severed this connection and is now employed in a similar capacity with the Warner Co., also of Philadelphia.

Willis Stutson, manufacturer's agent, has relinquished his post with the Dahlstrom Metallic Door Co., of Chicago, to become a partner in the firm of Stutson & Pruden, of the same city.

C. Stumhofer, who has been serving the Salisbury Axle Co., of Jamestown, N. Y., as a designer, has been transferred to that company's Toledo, Ohio, branch and promoted to the post of chief draftsman.

Ralph K. Super is now serving the International Motor Co., of Allentown, Pa., in the capacity of experimental engineer, having severed his connection as manager with the Terminal Garage, of the City of Washington.

Robert A. Swalm, engineer for the Curtiss Aeroplane & Motor Co., has been transferred from the Garden City, Long Island, branch, to the Garden City, Pa., branch.

David R. Swinton, having relinquished his position as Detroit representative of the American Chain Co., is now chief engineer for the Eaton Spring Corp., of Detroit.

E. H. Swayze has severed his connection with the Studebaker Corp. of America, which he served as district service manager for the Portland, Ore., region, and is now vice-president of the Lineham Motor Corp., of Vancouver, Wash.

Arthur Y. Taylor, a former student of Union College, at Schenectady, N. Y., is now employed as an engineer with the McIntosh & Seymour Corp., of Auburn, N. Y.

Louis K. Teller, until lately general superintendent of maintenance for the Rubel Coal & Ice Corp., of Brooklyn, N. Y., is now serving the Ward Baking Co., in Brooklyn, as assistant superintendent of maintenance.

William T. Thomas, formerly consulting engineer, is now a director and consulting engineer for the Cunningham-Hall Aircraft Corp., at Rochester, N. Y.

Carl A. Thulstrup recently resigned his position as die designer and checker for the Doehler Die-Casting Co., of Pottstown, Pa., to accept a similar position with the Allied Die Casting Corp., of Long Island City, N. Y.

Max W. Thaete, former service manager for Allison Motors, Inc., of Denver, has accepted a similar position with Charles Schonlaw, automobile dealer, of Hollywood, Calif.

Walter Tiersch, until recently production engineer with the Orville Simpson Co., of Cincinnati, now occupies the position of purchasing agent for the company.

Ernst W. Toron has recently become technical director for Willy Vogel, Autozubehör, of Berlin, Germany. His previous connection was as a director with Dr. Ludwig Michaelis, Ingenieurburo, G. m. b. H., of Berlin, Germany.

George H. Townsend, who resigned as president of the Boyce Moto-Meter Co. last July, is now president of the Ava Motor Co., of New York City.

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